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The Effects of Modality Preferences and Presentation Modalities

on Learning and Recall

Gary M. Ingersoll

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The Effects of Presentation Modalities and Modality Preferences on Learning and Recall

A Thesis in

Educational Psychology

by

Gary Michael Ingersoll

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CHAPTER I

INTRODUCTION

The purpose of the present study was to investigate the recall and learning of material presented in a bisensory fashion, that is, via auditory and visual modalities, as a function of specific modality preferences for one or the other of the senses involved. Such studies seem essential if individual differences in modality preferences are to be identified and their possible interactive effects with different treatments determined.

Within educational lore, there is a commonly held belief that when material is presented by both auditory and visual means, learning is facilitated to a greater extent than when the same information is presented by either means alone (see for example, Dale, 1954). However, in a critical evaluation of the literature related to the topic of the auditory, visual, and audio-visual transmission of information, Travers (1964) was forced to conclude that the bimodal (or multimodal) presentation of stimuli may be more detrimental to or, at best, no more effective than, learning the same information presented by a single modality. Travers asserted:

> The audio-visual model of the past is fundamentally unsound and must be discarded. . . . Research shows that when redundant information is arriving at a rate equal to or greater than the information handling capacity of the individual, the <u>learner</u> functions as a single channel system accepting information from only one source. . . . [When] non-redundant information is transmitted through two perceptual

> systems . . . the two channels together do not result in the transmission of greater quantities of information than the use of one alone (Travers, 1968, pp. 20-21).

Upon closer examination, however, it appears that Travers' conclusions may be sufficiently imprecise to render them only partially useful in the development of instructional strategies. Travers fails to consider the possibility that the relationship between the two messages may vary from complete redundancy of information to materials of such a non-redundant nature that they are antagonistic. Further, although Travers suggests that the learner functions as a single-channel processing mechanism, no consideration is given to possible individual differences which might differentially affect performance in bisensory auditory and visual tasks. Snow and Salomon (1968) have pointed to the need for considering such aptitudes in the development of any viable theory of instruction.

The present investigation extended the study of aptitude by treatment interactions to instructional strategies employing auditory and visual modalities. More specifically, the intent was to determine the differential effects of aural and visual modality preferences on the learning and recall of independent information presented simultaneously over the two modalities.

Single Channel Processing Model

There are many theoretical positions related to the study of bisensory stimulation (e.g., Davis, 1967; Hebb, 1949). However, most clearly aligned with the peculiar problems associated with the simultaneous presentation of independent information across more than

one modality is Broadbent's (1958) limited capacity processing mechanism. Broadbent proposed a hypothetical human information processing mechanism which can process incoming information at a set rate. If that rate is exceeded or equalled by the simultaneous presentation of information to two or more sensory receptors, then all receptors except one are restricted in their input capabilities. All information from the sensory receptors is put into a short-term sensory storage system. The nature of the storage system provides that the information held therein is subject to immediate and rapid decay unless the information is rehearsed. When information is received by two receptors, that set of information which is processed, or rehearsed, first is hypothesized to be recalled more completely since the information held temporarily in storage suffers decay while the other is being rehearsed.

During dichotic listening tasks and its bisensory analogue, in which independent messages are presented simultaneously over two channels, there is a distinct tendency for subjects to respond with the information from one channel and then the other instead of as pairs as they are presented. Broadbent (1956; Broadbent & Gregory, 1961) and others (e.g., Dornbush, 1968; Madsen, Rollins & Senf, 1970; Senf, 1969), have viewed the tendency of subjects to emit responses from one modality prior to the other as supportive of the limited capacity model. The first emitted response, albeit a corollary of the original Broadbent model, is not a sufficiently stable measure under a variety of conditions to warrant its use in the definition of stable individual differences in modality preference.

Senf, Rollins, and Madsen (1967) for example found that response order is highly subject to mental set. Further, early pilot investigations by this author revealed that some subjects develop an effective strategy in which they process the "easiest" modality first and hold it in store while emitting the less preferred response. Nonetheless, it would follow, in the framework of the Broadbent model, that the less preferred modality which was emitted first but not processed first, would still suffer the greater decay. Thus, if information from one modality was consistently recalled with greater accuracy, this would indicate a preference for that modality insofar as it would be, by implication, the one consistently processed first within a given subject. However, Broadbent has failed to develop the possibility that in situations where information input exceeds the limits of the processing mechanism, stable individual differences may govern the flow of information. Further, no attempt has been made by Broadbent to describe the type of modality used in sensory storage.

Sensory Storage Systems

Sperling (1963) argued that both auditory and visual information are transformed into an auditory store. In later reports, Atkinson and Shiffrin (1968) and Phillips, Shiffrin and Atkinson (1967) proposed an auditory-verbal linguistic (AVL) model similar to Sperling's in describing the function of a short-term memory storage buffer. They propose separate sensory registers prior to short-term store, however, information is made compatible with AVL store before entering short-term store. This is essentially the

same type of model as that proposed by Sperling for the conversion of visual information input to an auditory store. More recently, Crowder and Morton (1969) have proposed an auditory input system which parallels Sperling's model in which auditory information is input into a precategorical acoustic store in much the same manner as visual information is forced into and out of Sperling's visual store. Although Atkinson and Shiffrin (1968) consider the possibility that other storage modalities may exist (e.g., temporal storage) they seem content to assume that the nature of any storage modality parallels the AVL store and that high recency effects, typically found in free-recall, should be evident throughout (Phillips, Shiffrin & Atkinson, 1967).

The proposition that auditory and visual information are both stored auditorily is not universally accepted. Neisser (1967) has proposed separate echoic (auditory) and ikonic (visual or imaginal) storage systems. Murdock (1966, 1967) and Murdock and Walker (1969) have viewed evidence gained from their own and others' research as supportive of a separate sensory storage model. In their short-term memory experiments Murdock and his colleagues found slightly greater primacy effects for visual inputs and greater recency effects for auditory input. That is, when response probability was plotted as a function of input modality and serial position of the stimuli, a pattern similar to that shown in Figure 1 was identified. On the basis of these expectations, a subject who preferred one or the other of the two sensory storage systems, in learning and recall would accentuate that pattern which corresponds to the favored modality. Thus, an individual who preferred the auditory modality

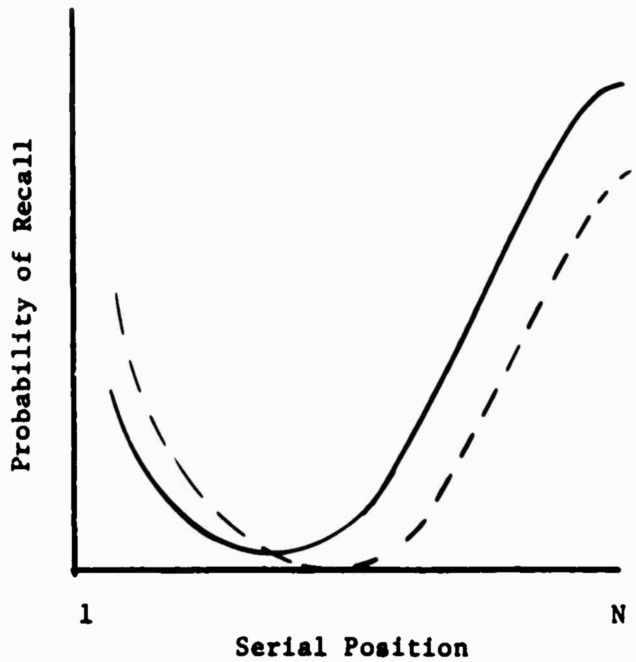

Figure 1. Generalized serial position curves for auditory (A) and visual (V) recall, based on Murdock (1966, 1967).

would exhibit enhanced recency effects during recall of auditory material while the one who was visually oriented, would display enhanced primacy effects in the recall of the visual stimuli.

Purpose of This Investigation

The present investigations are oriented toward identifying aural and visual modality preferences during bisensory auditory-visual stimulation which are stable across tasks and populations of subjects. The principal model from which this investigation was initiated is Broadbent's (1958) limited capacity processing mechanism model described above. Briefly it proposes that an individual can allow a specific amount of information to enter the system within any given period of time. Information can be processed at a fixed rate and if that rate is superseded by the presentation of information simultaneously across more than one channel, the individual will monitor the flow of information by restricting or closing off the flow from one or more inputs until the rate of input no longer surpasses the capacity of the mechanism.

While Broadbent's model fails to define the role of definable individual differences in the processing of information, more current information processing models, suggest the importance of monitoring systems in which different response categories or biases are imposed on incoming stimuli. An example is the computer paralleling model of Atkinson and Shiffrin (1968) and Shiffrin and Atkinson (1969). In addressing themselves to the problem of simultaneous inputs, Atkinson and Shiffrin (1968) note, "The first decision the subject

must make concerns which sensory register to attend to. Thus, in experiments with simultaneous inputs from several sensory channels the subject can readily report information [from one channel] if so instructed in advance, but his accuracy is greatly reduced if instructions are delayed until after presentation" (p. 107). If, however, no instructions are provided, the individual must impose his own preferences for monitoring information. The extent to which this is done and the stability with which it is done, should be reflected in response output.

There is some evidence to suggest that modality preferences are influential in the processing of information. Thus, when information is presented simultaneously over auditory and visual channels at a rate in excess of the processing capabilities of the mechanism, it is assumed that the channel to which an individual will attend or the channel which is first processed comprises a stable trait, at least within the context of a single task (Broadbent, 1956; Madsen et al., 1970; Senf, 1969). These "modality preferences" which emerge in tasks where information is presented simultaneously across the auditory and visual channels, in excess of the processing capabilities of the mechanism, were the subject of investigation in the present study. That is, aural and visual modality preferences which result in differential processing of information presented across visual and auditory modalities were to be identified. Rather than view modality preference as a unique phenomenon within one task, the present study proposed to study the measure under other conditions than the task on which it was defined.

Implicit in most research comparing the effects of modality on learning and recall has been the assumption that these effects are to be found mainly in short-term or primary memory and that tasks which allow encoding or categorization would preclude the filtering effects of modality preferences or modality effects (Atkinson & Shiffrin, 1968; Crowder & Morton, 1969; Murdock & Walker, 1969; Shiffrin & Atkinson, 1969). There is, however, some very tentative evidence that presentation modalities may have some effect upon the encoding of complex material (Mowbray, 1952, 1953; Webb & Whalon, 1956).

Summary

The present investigation was considered as the initial stage in the development of a theoretical framework within which the generality and the limits of the construct "modality preference" were to be identified. Eventually, a nomological net, in which this construct is more fully defined should emerge as additional data defining the characteristics of aural attenders and visual attenders are gathered. Such investigations appear indispensable if modality preference, as a construct, is to be incorporated into a theory of instruction, as it eventually must be since so much of present day instructional strategies is dependent upon the presentation of materials via these two modalities.

CHAPTER II

REVIEW OF LITERATURE

This chapter is a critical summary of studies which are relevant to the general problem of the effects of presentation of non-redundant stimuli simultaneously over auditory and visual modalities. Methodological considerations and relationships to certain current theories of information storage will be included. Of particular concern, however, are those studies which have employed some aptitude measure as an independent variable.

Typically, studies which have been concerned with the effects of presentation modalities on learning and recall have been of two types. Either one modality has been compared to the other on some specific criterion (studies of the type which compare single channel auditory or visual presentation are included in this category) or the effect of presenting redundant information simultaneously over two modalities is compared to the presentation of the same information over a single modality. As a consequence, little attention has been directed toward an examination of the effects of presenting independent information simultaneously over two modalities. Only recently, following Broadbent's (1954, 1956, 1958) early studies of dichotic listening and its bisensory counterpart, has the topic of bisensory presentation of non-redundant information been considered in any systematic manner. Nearly all bisensory research has been conducted under the rubric of short-term memory research.

Results which have been extracted from unisensory experiments may not be fully relevant to the unique features which must be associated with bisensory presentation. However, some information may be gained by considering selected studies.

Auditory Versus Visual Presentation

Research in the area of auditory and visual presentation modalities and their effects on learning and recall have generally been directed at a comparison of the efficiency of the two modalities. For example, Schulz and his associates (Schulz, 1969; Schulz & Kasschau, 1966; Schulz & Hopkins, 1968a, 1968b) have carried out a program of research designed to compare the relative effectiveness of visual and auditory presentation on various verbal learning tasks. Schulz emphasizes the importance of such research as follows:

> It appears that detailed knowledge concerning the learning of aurally received material, comparisons of the learning of audio with visual presentation of material and the advantages and/or disadvantages of joint audio-visual presentation may have innumerable and significant potential applications in enhancing the effectiveness and efficiency of educational procedures (Schulz, 1969, p. 1).

Schulz, however, was forced to conclude that, by itself, presentation modality was not an overly potent variable. If, however, modality effects do exist, Schulz concluded that they must occur in the associative stage of learning.

Several investigators have studied the effects of presentation modality on short-term recall (e.g., Conrad & Hull, 1968; Cooley & McNulty, 1967; Corballis, 1966; Craik, 1969). Perhaps the earliest American work on this problem was conducted at Harvard by Munsterberg

(1894) who varied the mode of presentation between and within sets of stimuli. He used five Ss who were presented some 32 different combinations of aural and visual presentation. Munsterberg concluded that "when the two senses act together in recollection, they hinder each other. . . . When isolated, the visual memory surpasses by far the aural, when combined the aural excels the visual (Munsterberg, 1894, pp. 36-37).

Murdock (1966, 1967, 1968, 1969; Murdock & Walker, 1969) has conducted a concentrated program of research on the role of auditory and visual presentation modes on short-term memory. His results demonstrate an overall superiority for recall of stimuli presented auditorily than visually. In his earlier studies, Murdock used a serial-probe paradigm for his investigations. The paradigm originally introduced by Waugh and Norman (1965) consists of two parts. First, a list of items is presented in serial fashion. Second, immediately following the presentation of the list, E presents one member of the list (the probe) and S is asked to report the item that immediately followed the probe on the first presentation. Murdock (1966, 1967, 1968) used the word lists as stimuli and presented them either visually or auditorily. As shown earlier in Figure 1, the serial position curve for probability of recall demonstrated greater recency effect for auditory presentation. Further, there was evidence to suggest a primacy effect for visual presentation. However, due to the nature of the serial-probe paradigm, any primacy effects would be restricted since there really is no probe for the first item in the list. Murdock and Walker (1969) used a free recall paradigm

and found essentially the same pattern with more clearly defined primacy effects for visual presentation. However, when Craik (1969) restricted recall order by instructing Ss to start recall with the first items of the list rather than the last, he found strong primacy effects for both auditory and visual presentations. When recall was directed to begin with the last items in the list, the more traditional recency effects were found.

Missing unit paradigm. A paradigm which has not been used in the study of modality effects on recall, but which might be of value when studying bisensory memory, is the missing unit paradigm. Basically, this design consists of an initial definition of a finite set of units. All but one of the set is repeated in a random order and S is required to respond with the missing unit. This paradigm has been described in two independent sources. Buschke (1963a, 1963b; Buschke & Hinricks, 1968; Buschke & Lenon, 1967; Buschke & Lim, 1967) used what he has termed a missing-scan or missing-digit paradigm. Buschke defines a finite set of digits (e.g., 11-25) and randomly presents all but one and S is to respond with that missing digit. Buschke argues that the missing-scan offers a different approach to a short-term recall since it:

> evaluates relative retention in short-term storage through the distribution of errors of commission made in attempting to report the single missing item from a known set when all but one are presented in random order. The missing-scan involves retention only of item information about the occurrence of items, regardless of their order. The missing-scan requires encoding and storage of item-information about all items presented as well as concurrent evaluation in storage for selection of the one unit not presented (Buschke & Hinricks, 1968, pp. 1043-1044).

Yntema and Trask (1963) have offered another approach using somewhat the same paradigm under the rubric of search processes. They described a procedure in which five words were presented to S and then, after a very short pause, four of those five words were repeated in random order. The S's task was to identify the missing word. These investigators reported this procedure as pilot work but note that even with this small set of words, overall probability of recall was about .80. If the size of the set was increased it would be expected that the probability of recall would decrease and if, over several trials, words were systematically missing from each of the serial positions, a distribution of response probabilities would be found as a function of serial position. Such a distribution might offer some clarification of the nature of primacy effects for visual presentation.

Two important distinctions between the Buschke and the Yntema and Trask procedures should be noted. First, with the Yntema and Trask procedure, a finite set of elements is defined which is unique to a given trial. If these elements are randomly selected from a large pool of such elements, there is little likelihood that S will have any familiarity with the set. Under the Buschke procedure the set of digits would be fairly well defined prior to performing the task. Second, since with the Buschke procedure the set is placed into storage at some time prior to the experiment, there is no way to assess input order as a variable. Both Yntema and Trask and Buschke view the missing unit paradigm as involving search processes. That is, the S must cognitively check the status of the members of a known set as they occur and repeat the one remaining unit.

In comparison to the serial-probe paradigm, little is known about the nature of recall probabilities as a function of serial position from which a missing unit has been dropped. Further no comparison of modality effects has been investigated.

Bisensory Presentation

Far less research has been conducted using bisensory auditory-visual presentation than research comparing the efficacy of either modality singly. Mowbray (1952, 1953) Broadbent (1956) and Broadbent and Gregory (1961) conducted the early research in the area.

Mowbray (1952, 1953) presented two connected discourse passages simultaneously, one visually and one auditorily. Following the presentation, S was questioned to determine his level of comprehension of both passages. Mowbray concluded that the auditory presentation suffered more from simultaneous presentation than did the visual. Further, Mowbray argued that the easy passages suffered more during simultaneous presentation than did the difficult passages. The latter effect may be partially the result of an artifact since level of comprehension for the difficult passages must have originally been lower, therefore, the more difficult passages would be restricted in the amount of loss possible.

Essentially, Broadbent's work was more an attempt to test the stability of his limited capacity processing model (Broadbent, 1958) than it was to compare modality effects. The investigations were extensions of earlier dichotic listening studies in which separate digit-spans were simultaneously presented to each ear. Instead

of recalling the digits in temporal pairs, as they were presented, Ss tended to recall the digit-span from one ear and then the digit-span from the other ear (Broadbent, 1954). These results were replicated using bisensory auditory-visual stimulation (Broadbent, 1956; Broadbent & Gregory, 1961). That is, when digit-spans were presented bisensorily, Ss tended to recall the set presented to one sense prior to the set presented to the other sense.

When S is required to recall both sets from bisensory memory, an overall superiority of recall from auditory presentation has been found (Dornbush, 1968). Dornbush studied the effects of presentation rate and type of stimulus on bisensory memory. By varying the rate of presentation, she replicated earlier findings found with single modality auditory or visual presentation of digit-spans. That is, as the rate of presentation increased, recall of aurally presented items was facilitated (cf. Conrad, 1957; Fraser, 1958). As the rate of presentation decreased, the recall of visually presented items was facilitated (cf. Mackworth, 1962). Further, Dornbush also compared recall of numbers and letters under bisensory stimulation and found a higher level of recall for numbers. This is not overly surprising. Letters would be more susceptible to acoustic errors and thus reduce overall performance (Conrad, 1964; Wickelgren, 1966). In addition, the set of digits is a more frequently defined set of elements than the letters A through J, and the latter set is drawn from a much broader set of alternatives. Miller, Heise, and Lichten (1951) demonstrated that under fixed conditions of signal and noise, S was less likely to hear a word correctly if he knew it was one of

a large number of alternatives than if the set of alternatives was narrow and fairly well defined. Methodologically, her study suffers from a major flaw. By running Ss in auditorium size groups, she could not insure that the sets "recalled first" were indeed the ones S did write first. (During the present author's pilot work it was found that some Ss wrote down responses as soon as the stimuli occurred unless closely monitored.)

Individual Differences and Auditory and Visual Presentation

The possibility of individual differences in preferences for the processing and storage of information is not a truly new concept. James (1892) and Galton (1883), for example, were concerned with individual differences in auditory or visual imagery. Until the early 1920's, much anecdotal evidence appeared concerning such phenomena as eidetic imagery although Galton collected much data on the subject of imagery via questionnaires. This, however, is a somewhat different conceptualization than a preference for the modality by which material is presented.

The number of studies in which individual differences have been studied under conditions of bisensory stimulation is very small. This is not overly surprising since the overall amount of bisensory research has not been sufficiently large to encourage the inclusion of individual difference variables. Broadbent (1956), however, offered anecdotal evidence to suggest different response styles might exist. In his own research with bisensory digit-spans, Broadbent found that during recall, "there was no tendency for either sense to

be universally the one delayed. In general, each subject had his own consistent preference for giving the eye or the ear first." (Broadbent, 1956, pp. 147-148). This observation would be in accord with the limited capacity processing model which Broadbent proposes. However, the assumption that the first emitted response necessarily implies which modality was processed first may not be valid. The measure of response pattern is relatively unstable under different conditions and is susceptable to perceptual set (Senf, Madsen, & Rollins, 1967). Further, it is equally plausible that an S could adopt a strategy of rehearsing the favored channel while quickly spewing out the information presented on the non-preferred channel. (Individual reports by subjects during early pilot work by this investigator indicated that this is often the case. For instance, an S might report "The auditory was easy to remember so I wrote down the visual first.")

Madsen, Rollins and Senf (1970) have studied the stability of response patterns to bisensory presentation across different presentation rates. It has been argued that as presentation rate decreased (pairs/sec) the ability to recall the information as pairs rather than by modality increased. Madsen et al. (1970) argued however, that when Ss were used as their own control in a within-subject's design, their consistency across conditions was much more striking than any tendency to change with treatment conditions. However, Madsen et al. did not compare individuals who consistently responded by modality to those who consistently responded by pairs on any other task.

Senf (1969) compared response patterns of learning disorder children (LDC) with normal control children (NCC) and supported his

argument that the LDC group was less likely to construct inter-sensory associations than its NCC counterpart. Senf argued that this inability would restrict the development of reading skill. Senf noted that the LDC group displayed a marked tendency to respond with the auditory channel first whereas the NCC were fairly evenly distributed in the tendency to respond with either modality first. Following the limited capacity processing model, Senf argued that the modality emitted first represented a preferred modality. However, Senf felt that response style was a source of confounding to the treatments in which he was most interested. He attempted, therefore, to minimize the effect of response style by instructing Ss to respond in a predetermined order.

In a single modality presentation study, James (1962) tested the hypothesis that Ss would learn more from material presented in a manner congruent with that which they perceived as advantageous than when the mode of presentation was incongruent with their preferences. James asked Ss to declare whether they preferred a reading or lecture presentation or had no preference. James then presented Ss material to be learned in either the preferred or non-preferred manner. He found a significant interaction ($p < .05$) for learning as a function of reported presentation preference and the actual mode of presentation. The nature of that interaction is shown in Figure 2. Recall was clearly more efficient for both groups under the reading condition. However, the magnitude of the difference in comprehension of the material under lecture and reading presentations is very large for those Ss who indicated that reading was their preferred mode. For those Ss who indicated a preference for lecture presentation, the

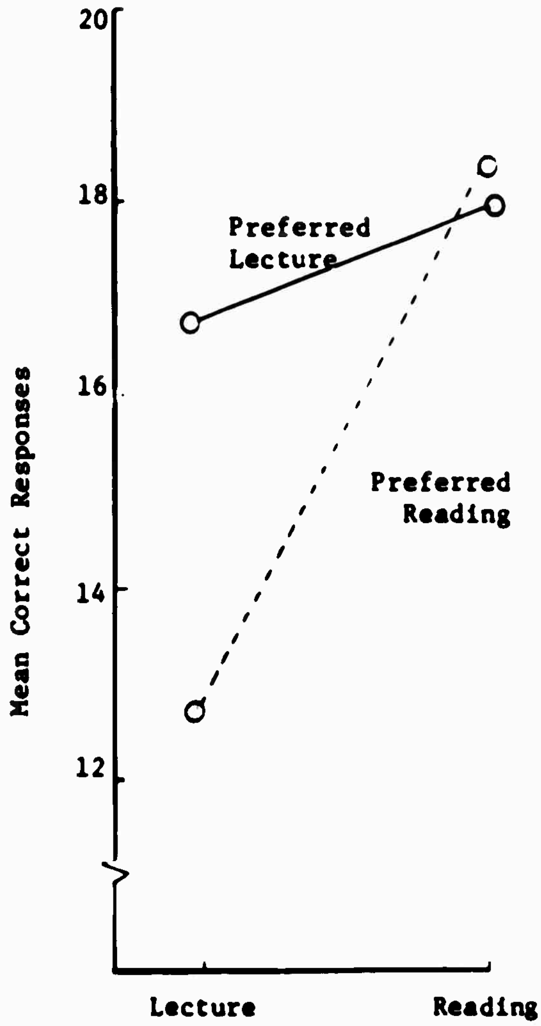

Figure 2. Recall as a function of presentation preference and actual mode of presentation, based on James (1962).

Note: This graph is plotted with means kindly provided by Dr. Newton James

two means were essentially equal, although they did learn much better under lecture conditions than did Ss who indicated a reading preference. Although it would be of some value if the James (1962) study were replicated using more controls on the exposure of materials such as those suggested by Webb and Whalon (1956), the results of that investigation are certainly encouraging for the study of aptitude by treatment interactions.

Using a recognition task, Carlson (1937; Carlson & Carr, 1938) found fairly stable tendencies across several trials for some Ss to consistently attend to visual (featural) or vocal (articulatory) cues of verbal stimuli during encoding and recall. The extent of this preference was measured by errors of commission during a recognition task.

Summary

The existence of auditory and visual modality preferences which are shown by differential responding to preferred and non-preferred modalities would greatly enhance the study of presentation modalities and their effects on learning and recall. Further, the identification of modality preferences which demonstrated magnified patterns of recall for their respective modalities would clarify and support Murdock's (1966, 1967) position. That is, visual attenders should not only recall more visual stimuli, but recall should show marked primacy effects. Conversely, aural attenders should not only recall more auditory stimuli, but their recall should show marked recency effects.

The present study is necessarily an exploratory one in the sense that the range of experimental literature directly applicable to the problem of individual differences in response patterns to bi-sensory auditory-visual stimulation is indeed small. Little research has been conducted on the identification of differential modality preferences and, insofar as the present author is able to determine, no research has been done in which modality preferences were defined as they are in the present studies, i.e., as a difference in likelihood of recall of visual and auditory stimuli. Further, with the exception of James' (1962) single sensory study, this investigator has not found a study in which a modality preference was identified on one task and performance on a second task was predicted as a function of that preference.

CHAPTER III

EXPERIMENT I

The first investigation was comprised of two parts. In the first task, a measure of visual preference or aural preference was defined and developed. It was subsequently used to predict performance on a second and independent task. The experiment was intended to establish the reliability and validity of the construct of modality preferences and of their effect on the recall of nonredundant materials presented simultaneously over both the auditory and visual modalities.

Method

A bisensory digit-span task, of the type used by Broadbent (1956; Broadbent & Gregory, 1961) and Dornbush (1968) was used to determine whether an S was an aural attender or a visual attender. Two digit spans were presented simultaneously; one digit-span was presented visually and a second, and different digit-span, was presented aurally. Modality preference was defined by Ss performance during the recall portion of five criterion trials. The S who tended to recall the visual digit-spans more correctly than those presented aurally on those five criterion trials was classified as a visual attender. Conversely, the S who tended to respond more correctly to presentation via the auditory channel was classified as an aural attender.

A second task was presented to S in which a bisensory modification of the missing unit paradigm, described by Yntema and Trask (1963) was used. In the Yntema and Trask procedure, five words were first presented to S. Then four of the five words were repeated in random order. The S's task was to respond with the missing word. However, in the present investigation, two independent sets of five words were presented simultaneously, one visually and one auditorily. Therefore, S's task was to respond with two missing units, one from the set presented visually and one from the set presented auditorily. Ten trials, in which words were dropped equally from each of the five serial positions, were administered. An overall comparison of performance on the missing units task as a function of aural and visual presentation modalities, was made. However, the principal analysis compared performance of high visual attenders and high aural attenders. The two extremes of modality preference served as a between-subjects dimension. The design was a factorial design with 2 between and 2 x 2 x 5 within-subjects dimensions where responses to auditory and visual stimulation and two groups of five trials served as the within-subjects dimensions.

Subjects

Undergraduate students at The Pennsylvania State University who were enrolled in an introductory course in educational psychology served as the Ss. Participation was voluntary and not part of any course requirements. However, Ss were awarded points toward their final grade for participating in the experiment. A total of 69 Ss, all naive to bisensory reception studies, participated.

Stimuli, Materials, and Apparatus

The integers 1 through 0 (pronounced "zero") were used as stimuli for all digit-spans. Integers were randomly assigned to four-digit digit-spans with the restriction that the same figure could not occur twice within the same bisensory trial. Thus, a number could not occur twice within a single digit-span nor could it occur in the digit-span which was presented simultaneously on the other channel. The digit-spans used are presented in Table I.

Stimuli for the missing units task were monosyllabic words, randomly selected, without replacement, from a pool of 400 words found in the Thorndike-Lorge (1944) 1000 most common words. Homophones (e.g., son or sun) were eliminated from the pool of words to minimize confusion due to response ambiguity on the aural presentation. Proper nouns and numbers were also eliminated from the pool. Care was taken to insure that verbal associates did not occur within a set. The sets of words in each of the lists are presented in Table II. In each set, the underlined word represents the word that was eliminated on the second presentation and thus was the correct response.

Visual Stimuli. Visual stimuli were made from slides prepared with Thermofax (#24) silver-negative transparencies. Projected stimuli were light figures on a dark field.

Auditory stimuli. Auditory stimuli were pre-recorded on magnetic tape with a Wollensak tape recorder. Stimuli were pronounced clearly, with no inflections, by a male E. The same E recorded all stimulus tapes.

TABLE I

DIGIT-SPANS USED IN THE
DEFINITION OF MODALITY PREFERENCES

Trial	Digit-Spans		Pre-Instructions
	Visual	Auditory	
1	2056	9137	Visual
2	7526	8309	Auditory
3	8940	2637	Auditory
4	8326	1405	Visual
5	2315	7489	Auditory
6	0543	1786	Visual
7	1486	7035	Visual
8	3897	6451	Auditory
9	5762	4918	Visual
10	9031	2685	Auditory
11	9451	2307	None
12	4069	3752	None
13	2417	6389	None
14	9735	0486	None
15	3860	1542	None

TABLE II

FIVE WORD LISTS OF MONOSYLLABIC WORDS GENERATED FROM THE THORNDIKE-LORGE 1000 MOST COMMON WORDS

Visual					Auditory				
Box	Found	Fear	West	Bright	Word	Small	Same	Lead	Blood
Spot	Bed	Work	Joy	Past	Far	Six	Cloud	Smell	Watch
Lost	Want	We	Inch	Smoke	Boy	Both	Hurt	Rock	Black
Wall	Stone	Ten	Back	Chair	Born	Young	Face	Sold	With
Came	Force	Fruit	Point	Book	Shall	Mine	Warm	Kept	Call
Sir	Might	Salt	End	Tip	Now	Said	Forth	Store	Was
Fly	Keep	Hang	Nice	Ought	Game	Square	Fort	Wind	Time
Beat	Each	Chain	Short	We	Food	Paint	Start	Since	Try
Bird	Fall	Safe	Held	Day	Smile	Were	Trade	So	Mount
Guide	Shape	Ride	Date	Play	Drop	Hot	Bit	Off	Mind

Note: The underlined word in each set is the word which was eliminated on the second presentation.

When presenting a visual stimulus array (e.g., a digit-span) the members of the array can be presented at once (simultaneously) or the members of the array can be presented one at a time (sequentially). Stimulus members of an auditory array can only occur sequentially. Thus, to maintain parallel modes of presentation, both auditory and visual presentations of stimulus arrays were sequential.

Apparatus. Visual stimuli were rear projected onto a translucent screen by a Kodak Carousel Projector and auditory stimuli were presented via a Wollensak tape recorder through an external speaker. Synchronization of the auditory and visual signals was governed by a Kodak Carousel Sound Synchronizer, Model 2. Auditory stimuli on the magnetic tape were timed such that the "ready" signal initiated the presentation of the first slide of an array. As each slide appeared, an auditory signal initiated the next slide in the series. Presentation of stimuli on both modalities was suprathreshold and at a level not uncomfortable to S. The digits were presented at a rate of one every two seconds on each channel. The limitations of the apparatus restricted the exposure of the visual stimulus to approximately .8 seconds from onset to offset with a 1.2 second interstimulus interval. The exposure interval is slightly longer than the arbitrary .5 seconds used in the Dornbush (1968) study.

Procedure

A bisensory digit-span task and bisensory missing-unit task were presented successively. Upon arrival at the laboratory, S was seated in front of a translucent screen upon which was projected a

focus pattern. When S was comfortably seated and ready, he was given instructions as to the nature of the bisensory task in which he was to perform. He was then instructed that for the first ten bisensory trials, he would be told immediately prior to each trial which digit-span (modality) he should recall first. The modality to be recalled first was randomly determined (see Table I). Following these ten trials, S was given five additional trials without pre-instructions. He simply was told that he should recall the numbers in whatever order he felt was most comfortable for him. Performance on these five trials served as the measure of attending performance which was defined by the magnitude of the difference between the number of auditory and visual stimuli recalled. Responses were scored not only for correct retrieval of the units but also for retrieval of the correct temporal position, i.e., the inversion of two digits during recall would constitute an error.

Following the bisensory digit-span task, S was given instructions describing the missing units task. He was told that his task was to identify the missing word from two independent sets of information presented simultaneously over the two modalities. Written recall was used for all studies. The complete instructions for the two tasks in Experiment I, described above, are presented in Appendix A.

Results

Experiment I was conducted to develop a measure of sensory attending preference (visual or aural) which would predict performance

on an independent task. It was hypothesized that aural and visual attending preferences, as defined by the test measure, would interact with bisensory stimulation to affect the recall of visual and auditory stimuli. It was also hypothesized that individuals who were characterized by one or the other modality preference would accentuate differences in those recall patterns typically associated with auditory and visual recall: thus, it was expected that greater primacy effects would be obtained in the recall of visual stimuli by visual attenders while greater recency effects would be obtained in the recall of auditory stimuli by aural attenders.

Modality preferences were defined by the magnitude and direction of the differences between the number of auditory and visual scores on the test task. The distribution of scores was thus a distribution of difference scores with negative scores indicating a visual bias and positive scores indicating an auditory bias. Since there has typically been greater overall auditory recall, it would logically follow that the distribution should itself show a positive bias. The scores of those <u>S</u>s who fell at the extremes of the continuum were selected for further analysis. For the initial study, an arbitrary cutoff point of ± 3 was established. In addition, multiple regression coefficients were computed for the entire range of <u>S</u>s using the auditory and visual scores on the modality preference task as independent variables and auditory and visual performance on the missing units task as dependent measures.

Estimate of Reliability of the Modality Preference Measure

Reliability measures on the modality preference task may not be entirely meaningful in the traditional sense since the measure of auditory or visual preferences was based on the difference of an individual's two scores. A composite total of the number correct on both modalities obviously lacks meaning for the purpose of the present study. For example, an auditory score of 18 and a visual score of 11 would produce the same predictive score [7] as would an auditory score of 15 and a visual score of 8. Thus, while they have the same predictive value, the aggregates are not the same. Further, since the group was relatively homogeneous (all of the Ss were college students) there was a tendency for some Ss to cluster near ceiling.

An estimate of the reliability of the instrument was obtained by using a modification of traditional analysis of variance measures of reliability. The difference score for each of the five trials served as single observations and the sum of these observations was equal to the difference of the total scores. The aggregate difference then serves as a meaningful composite score which can be used in such a procedure. The analyzed matrix is 5 x N matrix of difference scores.

This analysis with a sample size of 69, yielded a reliability estimate of $r_{xx} = .65$. The coefficient offers an index of the internal consistency of the set of observations.

Distribution of Modality Preference Scores

The possible range of scores for modality preferences was from +20 to -20, however, the range for this sample was from +14 to

-14. The mean of the distribution was +1.43 with a standard deviation of 4.51. This implies an aural bias in the overall population (an unbiased sample would show a mean of 0). If the population was not biased, that is if there was an equal probability that an S could respond in either manner favoring either the aural or visual side, then the distribution might approach a binomial normal distribution. However, the distribution does not fit that criterion as is indicated by $\chi^2 = 41.67$, $df = 10$, $p < .01$. Further, the mean of the distribution deviates from 0 as indicated by $t = 2.63$, $df = 68$, $p < .01$.

Correlations Between Modality Preference and Performance on the Missing Units Task: Experiment I

Performance on the missing units task was expected to be related to performance on the preference measure. The range of scores was from high negative scores indicating a visual preference to high positive scores, indicating an aural preference. Accordingly, these scores were positively related to performance on the auditory portion and negatively related to performance on the visual portion of the missing units task.

The correlation between the modality preference score and performance on the auditory portion of the missing units task for all Ss was found to be $r = .11$ and the correlation with recall of visual stimuli, $r = -.23$. Although neither of these correlations differed significantly from $r = .00$, a comparison of non-independent correlations (Glass & Stanley, 1970) yielded $z = 1.73$, $p < .05$ (one-tail) indicating that they did differ from each other. Auditory and visual performances on the two portions of the missing units task, as measured

by the total number of items correctly identified, were negatively correlated $\underline{r} = -.44$, $\underline{p} < .01$.

The inter-correlations between the number of correct responses for auditory and visual recall in both the modality preference task and the missing units task are presented in Table III. These correlations were based on the aggregate auditory and visual scores for all Ss for each task. In terms of simple linear regression these correlations indicated that neither auditory nor visual scores were predictable from the number of correct visual responses on the preference task. However, a much stronger relationship was found between auditory recall on the preference task and recall on the missing units task of stimuli presented by auditory means. The two auditory scores were found to be positively correlated ($\underline{r} = .37$, $\underline{p} < .01$) whereas visual recall on the missing units task was negatively correlated with the auditory score on the preference task ($\underline{r} = -.18$, ns).

When multiple regression coefficients were calculated, using auditory and visual performance on the modality preference task as the independent variables and auditory or visual performance on the missing units task as dependent variables, the auditory score on the preference task was the single most powerful predictor of performance on the two dependent variables. However, while the multiple correlation of the two independent variables with auditory performance increased the overall correlation to $\underline{r} = .38$, the multiple correlation for the visual dependent variable was increased to $\underline{r} = .24$, $\underline{p} < .10$. The beta weights associated with the auditory predictor (X_1) differed rather markedly for the auditory (Y_1) and visual (Y_2) dependent

TABLE III

INTER-CORRELATION MATRIX OF AUDITORY (A) AND VISUAL (V) RESPONSES FOR THE MODALITY PREFERENCE (MP) TASK AND THE MISSING UNIT (MU) TASK

	MP A	MP V	MU A
MP V	.16		
MU A	.37*	.16	
MU V	-.18	.13	-.44*

Note: All coefficients are Pearson product moment correlations based on the entire sample ($n = 69$). Those coefficients which are marked * are significant ($p < .01$).

variables. The beta weights associated with the visual predictor (X_2) remained essentially constant for both dependent variables. The two multiple regression equations are presented below:

$$Y_1 = .256\ X_1 + .056\ X_2 - 2.623$$

$$Y_2 = -.106\ X_1 + .065\ X_2 + 3.056$$

When X_2 was held constant, within the possible range of 0 to 20, and the regression lines plotted within a two dimensional space at that level of X_2, the regression lines for the two dependent variables intersected, thereby indicating a disordinal interaction. The intersection of these two regression lines (or planes) is displayed in Figure 3.

The ratio of the amount of variance that was due to regression to that which was about the regression line was found to be significant for predicting Y_1 (F (2,66) = 5.63, p < .01) but the same ratio for the regression line for Y_2 was not (F (2,66) = 1.95, ns).

Analysis of Variance for the Missing Units Task: Experiment I

Earlier bisensory studies of short-term recall demonstrated that material presented by auditory means was found to be recalled more readily than units presented by visual means (Dornbush, 1968). Accordingly, an overall comparison of the mean number of correct responses for all Ss to the auditory and visual missing units was made. This analysis yielded t = 1.50 (df = 68, p < .10, one-tailed test). In addition, examination of the distribution of responses as a function of presentation modality and the serial position from which the

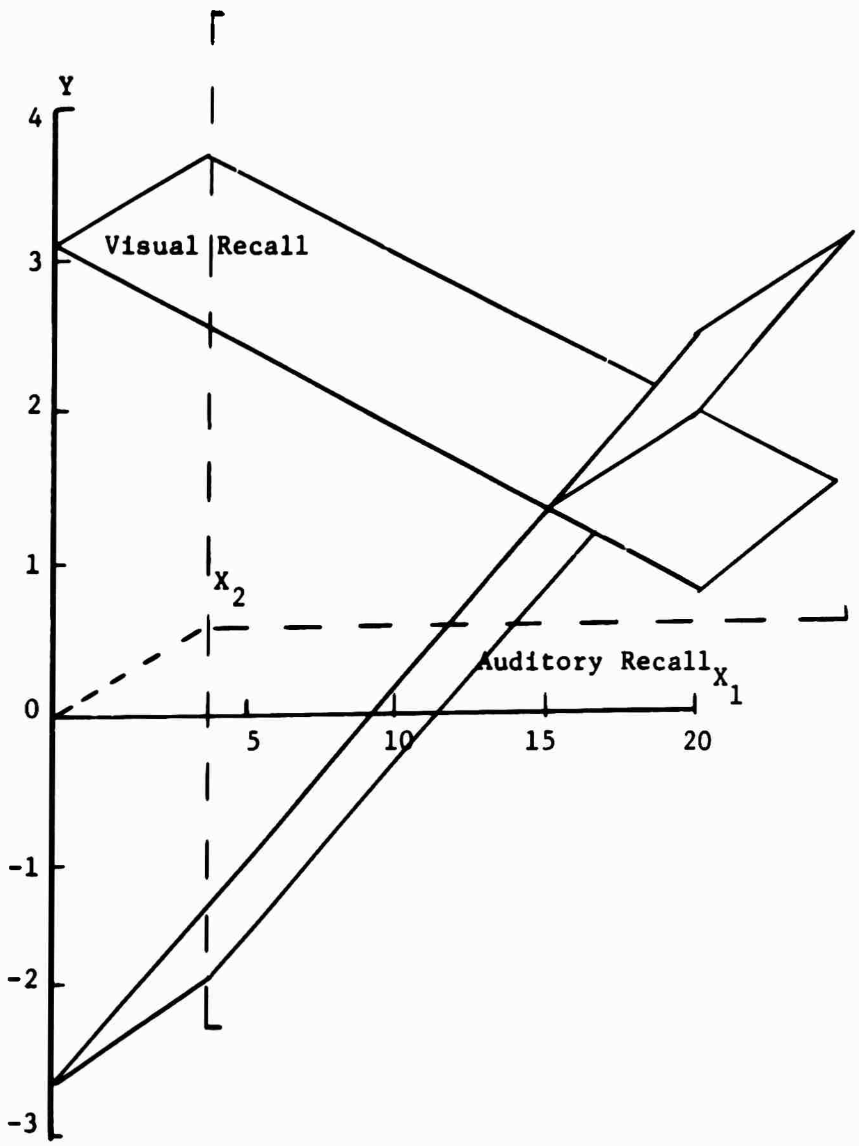

Figure 3. Multiple regression planes for auditory and visual recall on the missing units task as a function of auditory (X_1) and visual (X_2) recall on the modality preference task.

unit was eliminated offered some support for greater recency effects for auditory recall than for recall of visual stimuli. This result supports earlier findings in short-term recall experiments where the effects of unisensory auditory and visual presentations were compared (e.g., Murdock, 1966, 1967). The distribution of the mean number of correct responses as a function of presentation modality and serial position is presented in Figure 4. The primacy effects sometimes found in unisensory visual presentation (e.g., Murdock, 1966, 1967) were not replicated in this distribution of scores.

In the principal analysis of these data, performance of high aural attenders and high visual attenders, as defined by performance on the modality preference task, was compared. A repeated measures design with 2 between-subjects dimensions and 2 x 2 x 5 within-subjects dimensions was employed. Auditory and visual preferences comprised the between-subjects variable. Auditory and visual presentation modalities across the ten trials which were blocked into two sets of five trials (one for each of the five serial positions) were the within-subjects dimensions. Unequal cell _n_'s were maintained. Of the 69 _Ss_, 24 _Ss_ had scores greater than +3 and were identified as aural attenders and 16 _Ss_ had scores less than -3 and were identified as visual attenders. A summary of the results of this analysis is presented in Table IV.

Neither the main effects of attending preference nor the mean number of items recalled as a function of presentation modality was significant ($p > .10$). The significant interaction ($p < .05$) was found between the effects of sensory attending preference and

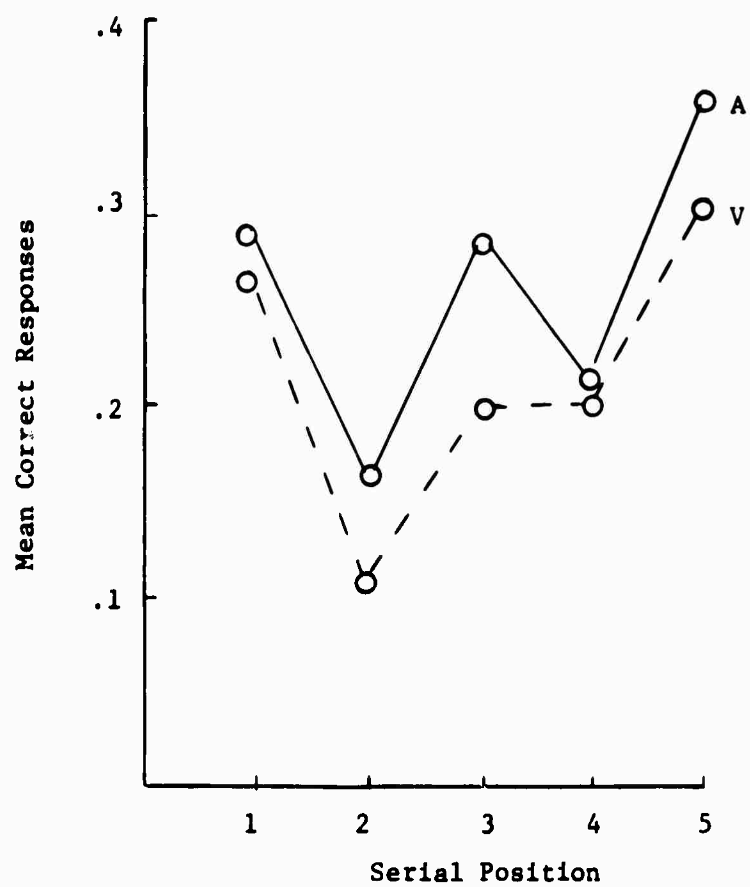

Figure 4. Recall of auditory (A) and visual (V) missing units over each of the serial positions for all Ss.

TABLE IV

SUMMARY OF THE ANALYSIS OF VARIANCE OF NUMBER OF CORRECT AUDITORY AND VISUAL RESPONSES DURING A MISSING UNITS TASK AS A FUNCTION OF MODALITY PREFERENCES: EXPERIMENT I

Source	df	MS	F	p
Between-Subjects				
Modality Preferences (A)	1	0.017	0.079	
Error (b)	38	0.213		
Within-Subjects				
Presentation Modalities (B)	1	0.080	0.159	
A x B	1	3.575	7.096	<.05
Error (w_1)	38	0.504		
Sets of Trials (C)	1	1.280	9.531	<.01
A x C	1	0.017	0.126	
Error (w_2)	38	0.134		
Serial Position (D)	4	1.308	8.141	<.01
A x D	4	0.161	1.003	
Error (w_3)	152	0.160		
B x C	1	0.080	0.621	
A x B x C	1	0.025	0.196	
Error (w_4)	38	0.128		
C x D	4	0.202	1.417	
A x C x D	4	0.160	1.124	
Error (w_5)	152	0.142		
B x D	4	0.314	1.979	<.10
A x B x D	4	0.073	0.457	
Error (w_6)	152	0.159		
B x C x D	4	0.158	1.008	
A x B x C x D	4	0.007	0.041	
Error (w_7)	152	0.157		

presentation modality is graphically displayed in Figure 5. There it can be seen that visual attenders correctly recalled more missing words from the series presented visually than from the series presented auditorily. Using procedures suggested by Kirk (1969), the difference was found to be significant. As hypothesized, the comparison of the means for visual attenders indicated that they recalled more visual ($\bar{X} = 3.06$) than auditory ($\bar{X} = 1.62$) missing words ($t = 1.83$, $df = 28$, $p < .05$, one-tailed test). Conversely, the aural attenders recalled more auditory ($\bar{X} = 3.08$) than visual ($\bar{X} = 1.79$) missing words ($t = 2.02$, $df = 38$, $p < .05$, one-tailed test).

The patterns of recall for the two groups across trials are displayed in Figures 6a and 6b which show that auditory recall by the aural attenders is markedly superior to recall of stimuli presented visually. The pattern is such that, for aural attenders, the greatest difference in recall of auditory stimuli is found in the recency portion of the curve; however, while visual attenders clearly favor items presented visually over all trials, the largest differences between auditory and visual presentation are to be found in the primacy portion of the curve.

Discussion: Experiment I

The results of Experiment I supported an information processing model which employs the notion of sensory attending preferences. Visual and aural attending preferences, were clearly stable across two independent tasks involving short-term memory. The

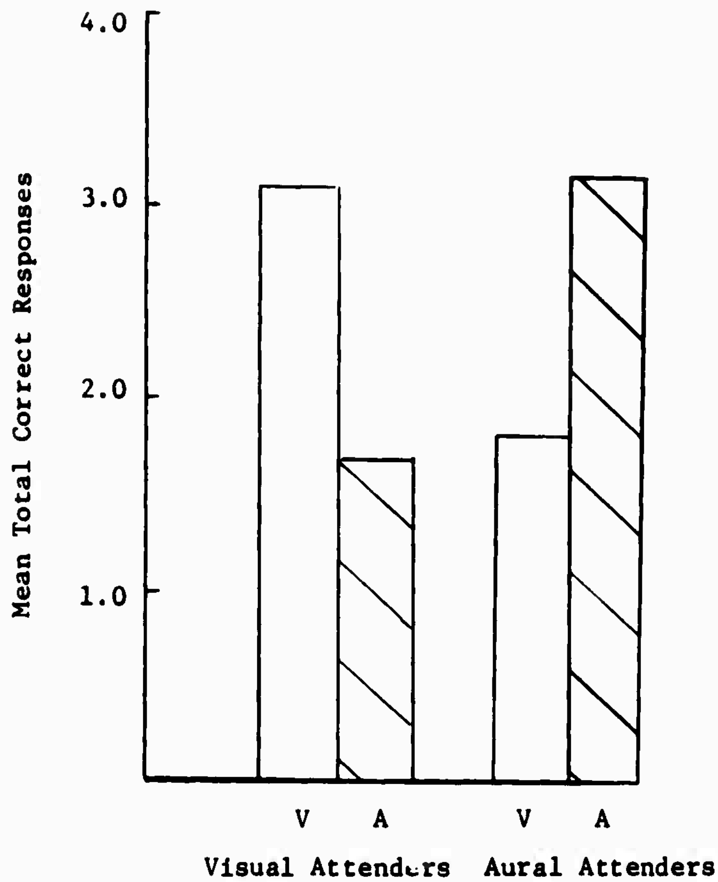

Figure 5. Mean total correct responses for visual (V) and auditory (A) stimuli by visual and aural attenders.

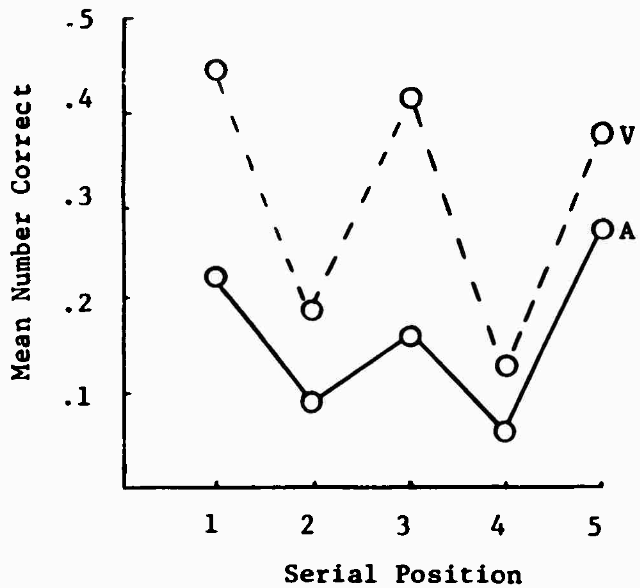

Figure 6a. Auditory (A) and visual (V) recall during the missing units task for visual attenders.

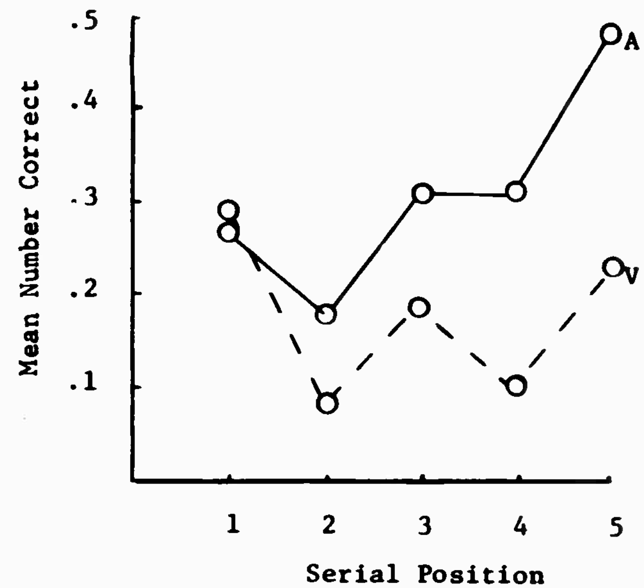

Figure 6b. Auditory (A) and visual (V) recall during the missing units task for aural attenders.

definitions of aural attenders and visual attenders were sufficiently distinct to warrant further investigation.

The results of the missing units task reaffirm findings from unisensory auditory and visual experiments (e.g., Murdock, 1966, 1967; Murdock & Walker, 1969) and from bisensory auditory-visual short-term memory experiments (Dornbush, 1968) which show an overall auditory superiority for recall of auditory stimuli when compared to the recall of visual stimuli. The results over all Ss indicate greater recency effects for auditory recall. However, primacy effects for visual recall were not obtained.

When the results obtained from Ss clearly identified as visual attenders and aural attenders were compared, the significant main effect of recall as a function of modality of presentation was negated and over all level of performance for the two groups did not differ. That is, both aural and visual attenders perform equally well on the missing units task as a whole. (Parenthetically, this does not preclude the possibility that the two groups may differ in performance on another type of task, especially one in which the presentation of information by one or the other of the modalities is favored.) However, when performance on the missing units task was analyzed as a function of modality preferences and presentation modalities, the hypothesized disordinal interaction was found. Visual attenders correctly identified more visual units than auditory units; conversely, aural attenders correctly identified more auditory than visual units.

The hypothesis of differential responding to auditory and visual stimuli by aural attenders and visual attenders was visibly

supported. Further, the distribution of responses across the temporal dimension of serial position corroborated the hypothesized accentuation of different response patterns to visual and auditory stimuli by those who displayed the respective modality preferences. Visual attenders not only correctly identified more visual missing units, but accuracy of recall was greatest when the unit was eliminated from an early serial position of the set (primacy). Aural attenders, on the other hand, correctly identified more auditory stimuli and recall was greatest when the units were eliminated from the latter (recency) part of the set. Thus, not only are modality preferences a stable phenomenon which extend across more than one task, the results also indicate that those preferences serve as monitoring or filtering systems which control the flow of information within the processing system. This point will be discussed in more detail in a later chapter.

Although the results support the hypotheses, they should most certainly be replicated, as Lykken (1968) suggests, with a new population and either different or a wider range of tasks. It would be more advantageous to the establishment of the generality of the construct if the results were replicated with a more heterogeneous population than college students. The use of a more heterogeneous group would allow the incursion of a wide range of cognitive variables to affect performance. If the results are replicable with a population of this nature, the construct of modality preferences could be presumed to be distributed over a wide range of subject populations. The use of a more variable sample would also allow the selection of more extreme scores from the ends of the preference continuum. More extreme

aural and visual attenders might produce response patterns more clearly associated with the predictions derived from a separate sensory storage model. A second experiment was thus conducted to replicate the results of this first study and to test the generality of the construct of modality preferences.

CHAPTER IV

EXPERIMENT II

Experiment II was a replication and extension of the first experiment. The intent was to test the generality of the effects associated with modality preference over a variety of tasks in a more heterogeneous population. The principal consideration remained to compare the effects of sensory attending preference on the learning and recall of non-redundant materials presented simultaneously over the auditory and visual modalities.

Method

Both the test for attending preference and the missing units task employed in Experiment I were retained for this experiment and were the procedures and materials for the two tasks. They were supplemented by three additional bisensory tasks, varying in degree of complexity. They were designed to measure the relationship between modality preference and performance on tasks requiring different levels of cognitive processes.

Bisensory subjective organization. In this task, groups of words which were exemplars of salient categories, as defined by the norms of Battig and Montague (1969), were presented in a bisensory manner. The assumption was that words which are members of salient

categories are easily stored and recalled in groups (clustered) during free recall. Thus, the extent to which presentation modality (preferred and non-preferred) acts to provide salient organizational categories for recall was studied in conjunction with the stability of normatively defined categories within and across categories.

Bisensory paired-associate learning. A modified study-recall paired-associate (PA) procedure was used. Thus, although both halves of the pairs were presented simultaneously, one term was presented visually and the other was presented auditorily. (The reader should note that neither could be defined as the stimulus or response in any spatial or temporal sense.) An intersensory association was required by S to process the material. On the recall portion of this task, S recalled both halves of the pair. In this procedure, described by Di Vesta and Ingersoll (1969), an entire list of paired-associates was first presented. The S was then instructed to reproduce as much of the list as he could, either complete pairs or parts of pairs. Nine trials were administered to all Ss.

The data for auditory and visual responses were analyzed in one analysis and the number of pairs recalled were analyzed in a second analysis. The inclusion of the latter measure in the former analysis would have produced significant results due to factors unrelated to the independent variable since the number of correct pairs must always be equal to or less than the fewest number of correct responses from either modality by itself. The first analysis was a repeated measures design with 2 between-subjects variables, and 2 x 9 repeated measures. The second analysis had 2 between-subjects and 9 repeated measures.

Bisensory connected discourse. In the connected discourse task, two paragraphs on different materials were presented simultaneously; *S* read one and listened to the other. Procedurally, this task differed in one important respect from all the others. The paragraphs used in the visual presentation were shown in their entirety to *S*. Whereas the other tasks maintained successive visual presentation, this task did not. Two sets of two paragraphs, differing in familiarity, were presented. Modality preference served as the between-subjects dimension while the two levels of familiarity of the passages over the two modalities served as within-subjects dimensions.

Materials

Bisensory subjective organization. Words which were exemplars of salient categories were selected (Battig & Montague, 1969). There were six words in each of the following six categories: I, four-footed animals; II, colors; III, articles of furniture; IV, fruits; V, parts of the human body; VI, articles of clothing. The words in each category were randomly assigned to one or the other of the two modalities. The sets of words used, described by categories and modalities, are presented in Table V.

Bisensory paired-associate learning. High frequency, monosyllabic four letter nouns which had high imagery and concreteness ratings were selected from the Paivio norms (Paivio, Yuille & Madigan, 1968). Words were randomly assigned to seven pairs. The generated list shown with imagery, concreteness, and frequency ratings can be found in Table VI.

TABLE V

CATEGORIES AND PRESENTATION OF MODALITIES OF WORDS USED IN SUBJECTIVE ORGANIZATION TASK

Category	Auditory			Visual		
I	Dog	Horse	Pig	Rat	Cow	Lion
II	Blue	Black	Brown	Red	Green	Pink
III	Desk	Bed	Couch	Chair	Sofa	Lamp
IV	Apple	Peach	Cherry	Pear	Grape	Plum
V	Legs	Eye	Foot	Head	Mouth	Nose
VI	Pants	Coat	Dress	Shirt	Socks	Hat

TABLE VI

IMAGERY (I), CONCRETENESS (C), AND FREQUENCY (F) RATINGS FOR WORD-PAIRS USED IN THE PAIRED-ASSOCIATE LEARNING TASK

Noun	I	C	F	Noun	I	C	F
Bird	6.67	6.96	AA	Fire	6.70	6.66	AA
Flag	6.60	6.94	A	Door	6.60	7.00	AA
Wife	6.53	6.52	AA	Bowl	6.30	6.90	A
Star	6.70	6.73	AA	Hall	6.37	6.72	AA
Coin	6.50	6.90	A	Dust	6.03	6.67	A
Girl	6.87	6.83	AA	Nail	6.50	6.96	A
King	6.27	6.34	AA	Camp	6.57	6.56	AA

Connected discourse. Two paragraphs each were adapted from introductory college texts in Art History (Elsen, 1962) and Biology (Villee, 1962). The same author was used within a topic in order to maintain some stability of writing style of paragraphs across modalities. The complete texts of all four paragraphs are found in Appendix B. Word and noun counts, which offer some index of comparability are presented in Table VII. Both measures were subjected to χ^2 analysis to determine whether scores seemed unduly different from each other. The χ^2 for words, using Yate's correction for a 2 x 2 table, was χ^2 ($df = 1$) = 1.62 and a similar analysis for the noun counts yielded χ^2 ($df = 1$) = .43. Neither of these statistics indicated significant differences ($p > .20$).

Apparatus

Visual stimuli were single items presented simultaneously by slides and auditory stimuli were presented by tape recorder as they were in Experiment I. The connected discourse passages were either presented in oral fashion from the tape recorder or a passage was typed using letter Gothic print on an 8 x 11 sheet of white paper. Copies were made using Xerox process.

Subjects

Students from the eleventh- and twelfth-grades at the Bald Eagle-Nittany High School, Mill Hall, Pennsylvania, served as *Ss* in this investigation. In all, 201 *Ss* were randomly selected from all Juniors and Seniors at that school. One female *S* was eliminated from

TABLE VII

WORD AND NOUN COUNTS FOR EACH OF FOUR PARAGRAPHS
USED IN THE CONNECTED DISCOURSE TASK

Passage	Words	Nouns
Cell Theory	247	49
Ecology	223	42
The Great Stupa	222	47
Stonehenge	228	44

the analysis for failure to follow directions. A complete description of the distribution of Ss by sex, grade, and homogeneous ability grouping, as defined by the Bald Eagle-Nittany School System, is shown in Table VIII. Due to the failure of some Ss to return for the second portion of the study, despite several written requests by E, complete data were not available on 7 eleventh-grade and 7 twelfth-grade Ss.

Procedures

Upon arrival at the laboratory, Ss were seated, in groups no larger than four, behind a large table in front of which was a translucent screen. On the screen was projected a 3 x 3 array of dots which served as a focus pattern. After Ss were seated, they were instructed about the general purpose of the study and instructed that there were actually two parts to the experiment and pointed out that it would be necessary for them to return in one week to participate in the second part. No specifics as to the nature of the tasks was given at that time. (All instructions are printed in their entirety in Appendix A.)

The Ss were then told about the sensory attending preference task. The procedure employed in Experiment I was followed. Thus, there were ten warm-up trials and five criterion trials.

Following the modality preference test, two of the four experimental tasks were presented. The order of presentation was such that each of the tasks was presented on the first or second day an equal number of times. Because of the lengths of the bisensory PA and missing units tasks, it was not possible to present both of those

TABLE VIII

DISTRIBUTION OF SUBJECTS BY
GRADE, SEX, AND SCHOOL DEFINED ABILITY GROUPING

Grade	Sex	Grouping						
		1	2	3	4	5	6	Total
12	Females	11	9	13	9	0	1	43
	Males	11	10	12	10	1	2	46
	Total	22	19	25	19	1	3	89
11	Females	19	12	14	6	3	0	54
	Males	3	16	7	12	5	0	43
	Total	22	28	21	18	8	0	97

Note: The school defined ability groupings were based on past achievement and selected ability measures. Group 1 was an academically oriented group while Group 6 was a special education classification. The other groups ranged in ability between those two ends of the continuum.

tasks on the same day. Thus, presentation of those two tasks were alternated between days and presentation of the other tasks varied around the PA and missing units task.

Bisensory missing units. The procedure for the missing units portion of this study was the same as that described in Experiment I. Unlike Experiment I, the missing units task did not necessarily follow immediately the modality preference task.

Bisensory subjective organization. The S was given instructions for a free recall task. No restrictions were placed on modality grouping nor was any indication given of possible salient categories for recall. Half the words were presented visually and half auditorily in a manner similar to the other tasks. Both sets of words were presented successively. Three presentation and recall trials were given.

Bisensory paired-associate learning. The procedure for this bisensory PA task differed from the traditional PA paradigm in that words pairs were presented in a bisensory fashion. One word was presented on one modality and its associate was presented simultaneously on the other modality. Neither dimension was defined temporally or spatially as the stimulus or response and no indications were given in the instructions concerning which item should be construed as the stimulus response. The S was to recall as much of the complete list as possible, either complete pairs or parts of pairs. The list of seven bisensory pairs was presented to all Ss for nine trials. The words were presented in a different random order on each trial.

Bisensory connected discourse. Paragraphs of approximately equal length were presented simultaneously over visual and auditory modalities. The visual paragraph was presented on a typewritten page which S was to read while listening to the simultaneous presentation of a paragraph on a tape playback. The written paragraph was given to S face down and was not turned over until the auditory presentation began. Further, in order to keep equivalent presentation times, S was instructed to stop reading and turn the page face down at the conclusion of the auditory paragraph. This procedure was repeated for two independent sets of paragraphs. The two sets remained the same for all Ss, that is, paragraphs were not alternated between sets. During recall, S was instructed to write as many facts as he could from both passages. Order of recall and format of recall was not considered important in the scoring procedure.

Results

Experiment II was a replication and extension of the first study. The same measure of modality attending preference was used without modification. Thus, the distribution of scores on that measure was again a distribution of difference scores. An auditory bias was expected to be found in the distribution of scores for this study also. However, due to the greater heterogeneity, the range of the scores, and concomitantly the variance, was expected to increase.

The same hypotheses proposed for Experiment I were expected to be confirmed in Experiment II since no modifications were introduced in either the modality attending preference task or the missing

units task. Similar predictions were offered for the additional tasks, i.e., modality preferences and modes of presentation should have different effects on recall. Mowbray (1952, 1953) found that with connected discourse, recall was greatest for the visually presented material. Thus, recall on the tasks which required higher level encoding processes was expected to be marked by visual superiority in contrast to the auditory superiority associated with short-term memory.

Similar analyses to those used in Experiment I were employed in the present study. Those <u>S</u>s who were selected from the two ends of the modality preference continuum constituted the between-groups dimension on each of the analyses of variance for the bisensory tasks used in Experiment II. Thus, Experiment II served to corroborate, with a more heterogeneous sample, those results found in Experiment I and extend the validation of the construct of attending preferences to other tasks.

<u>Estimated Reliability and Distribution Measures for Modality Preferences: Experiment II</u>

The reliability measure defined in Experiment I was used to obtain a reliability estimate for the modality preference data found in Experiment II. Using those procedures, with a sample of 199 <u>S</u>s, a reliability estimate $\underline{r}_{xx}$ = .66 was found. Quite clearly, this estimate does not differ from the $\underline{r}_{xx}$ = .65 found in Experiment I.

The range of difference scores on the modality preferences task was from +19 to -19 and the shape of the distribution is shown in the histogram presented in Figure 7. Those <u>S</u>s with a difference

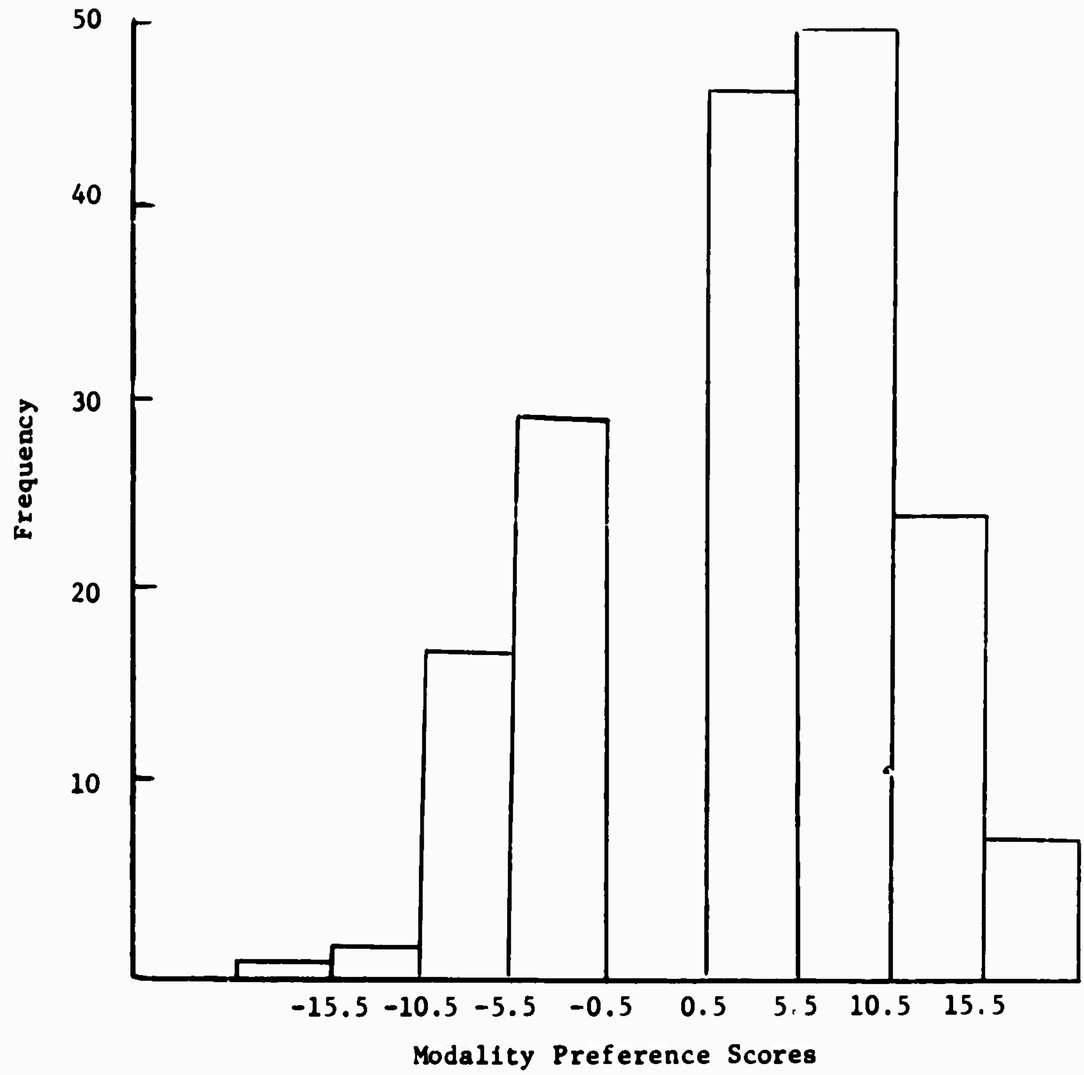

Figure 7. The distribution of modality preference scores for Ss used in Experiment II (Ss with a score of 0 are not included).

score of zero were excluded from the distribution shown. The distribution is visibly skewed and the bias favors the aural attenders. The mean of the distribution was 3.37 and the standard deviation was 6.73 which proves to differ from a hypothetical unbiased normal distribution of difference scores with a mean of 0.0, $z = 7.06$, $p < .01$. To maintain a measure of proportionality for the two extreme groups, approximately 15 percent of the total sample with low negative scores and 30 percent of the total sample with high positive scores were selected as the two extreme groups of visual and aural attenders. Since the range of scores was wider in this study than in the first, the cutoff scores differed. Those Ss with scores less than -4 were classified as visual attenders while Ss with scores greater than +7 were classified as aural attenders.

Correlations Between Modality Preference Scores and Performance on the Missing Units Task: Experiment II

The correlation between the modality preference scores and number of correct responses to auditory stimuli on the missing units task for Experiment II was $r = .10$ and the same attending preference score correlated $r = -.11$ with the number of correctly recalled visual items on the missing units task. Neither of those correlations differed from $r = .00$; however, they did differ from each other in the predicted direction, $z = 1.83$, $p < .05$. Recall of auditory and visual units on the missing units task was negatively correlated, $r = -.27$, $p < .01$.

Multiple correlation coefficients using the same independent and dependent variables defined in Experiment I, demonstrated that

auditory performance (x_1) on the attending preference task remained the stronger predictor for both auditory (Y_1) and visual (Y_2) performance on the second task. Visual performance (X_2) on the first task remained a poor predictor of performance on the second. The two regression equations, whose slopes are plotted in Figure 8 are presented below:

$$Y_1 = .16\ X_1 + .05\ X_2 - 1.09$$

$$Y_2 = -.03\ X_1 + .02\ X_2 + 2.34$$

The two regression planes display a disordinal interaction similar to that found in Experiment I. However, neither of the regression equations yielded significant *F*-ratios for the proportion of variance due to regression. Further, the slope for visual recall on the missing units task is essentially zero.

<u>Analysis of Variance for the Missing Units Task: Experiment II</u>

The design used here implied a mixed analysis of variance as described in Experiment I. The extreme groups on the modality preference dimension served as the between-subjects dimension. The two sets of five trials (in which the unit was dropped from each of the five serial positions) and the two modalities of presentation, served as within-subjects dimensions.

A complete summary of the analysis of variance is presented in Table IX. No differences in overall performance were found as a function of either attending preferences or presentation modalities. However, performance as a function of the interaction of attending

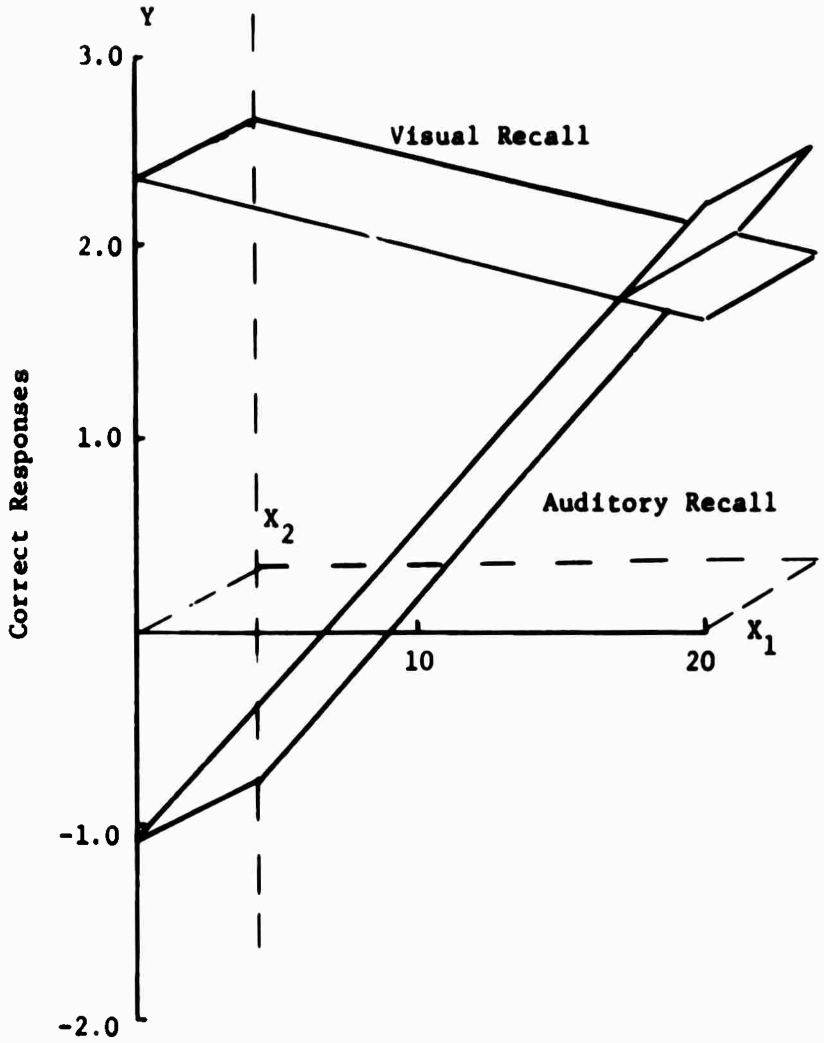

Figure 8. Multiple regression planes for auditory and visual recall on the missing units task as a function of auditory (X_1) and visual (X_2) recall on the modality preference task.

TABLE IX

SUMMARY OF THE ANALYSIS OF VARIANCE OF NUMBER OF CORRECT AUDITORY AND VISUAL RESPONSES DURING A MISSING UNITS TASK AS A FUNCTION OF MODALITY PREFERENCES: EXPERIMENT II

Source	*df*	MS	*F*	*p*<
Between-Subjects				
Modality Preferences (A)	1	0.10	0.48	
Error (b)	94	0.21		
Within-Subjects				
Presentation Modalities (B)	1	0.01	0.01	
A x B	1	1.76	4.42	.05
Error (w_1)	94	0.40		
Sets of Trials (C)	1	3.59	31.96	.01
A x C	1	0.01	0.09	
Error (w_2)	94	0.11		
Serial Position (D)	4	1.71	13.14	.01
A x D	4	0.27	2.04	.10
Error (w_3)	376	0.13		
B x C	1	0.09	0.50	
A x B x C	1	0.24	1.35	
Error (w_4)	94	0.18		
C x D	4	0.64	4.73	.01
A x C x D	4	0.11	0.81	
Error (w_5)	376	0.14		
B x D	4	1.01	7.47	.01
A x B x D	4	0.20	1.44	
Error (w_6)	376	0.14		
B x C x D	4	0.18	1.46	
A x B x C x D	4	0.14	1.13	
Error (w_7)	376	0.12		

preferences with presentation modalities was as predicted ($p < .05$). The data for this interaction are presented in Figure 9 where it can be seen that the interaction is disordinal. A one-tailed comparison of visual recall ($\bar{X} = 2.30$) to auditory recall ($\bar{X} = 1.40$) for visual attenders yielded $t = 1.68$, $df = 94$, $p < .05$, while a similar comparison of auditory recall ($\bar{X} = 2.20$) with visual recall ($\bar{X} = 1.80$) for aural attenders yielded $t = 1.21$, $df = 94$, $p > .10$. Both comparisons indicate that the results are in the predicted directions although statistically significant differences in recall were found only for visual attenders.

Recall, as a function of the serial position of the missing units, interacted with attending preferences though the effect was not significant ($p < .10$). The pattern of mean correct responses for aural attenders and visual attenders across each of the serial positions are shown in Figure 10. Examination of responses at the first and last serial positions yielded no difference favoring visual attenders during primacy ($t = 1.16$, $df = 376$, $p > .10$)[1] but, aural attenders are favored during recency ($t = 2.11$, $df = 376$, $p < .05$). Closer examination of auditory and visual responses for each group across serial positions reveals the patterns depicted in Figures 11a and 11b. A one-tailed comparison of visual ($\bar{X} = .32$) and auditory

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[1]The large degrees of freedom ($df = 376$) associated with the t-tests presented here is the df for the error term on which the sampling fluctuation is based. The mean squared error is a pooled estimate of error across cells and thus the df may be considerably greater than the n associated with any given cell.

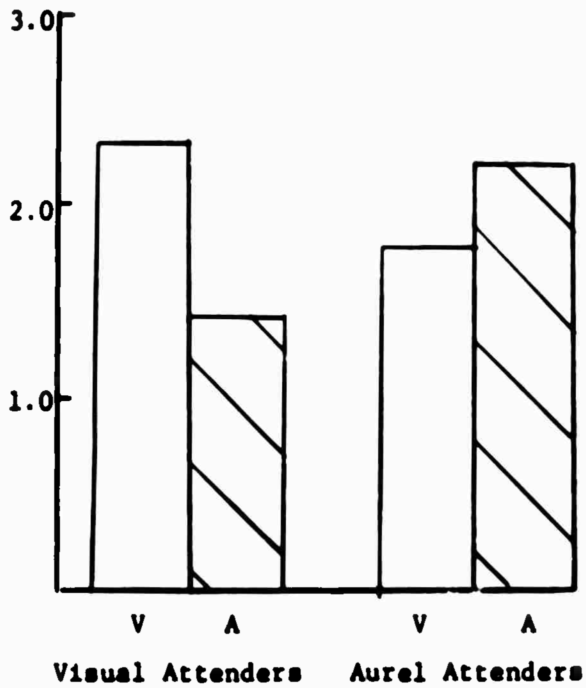

Figure 9. Mean totel correct visual (V) and auditory (A) items recelled by visuel ettenders end aurel attenders.

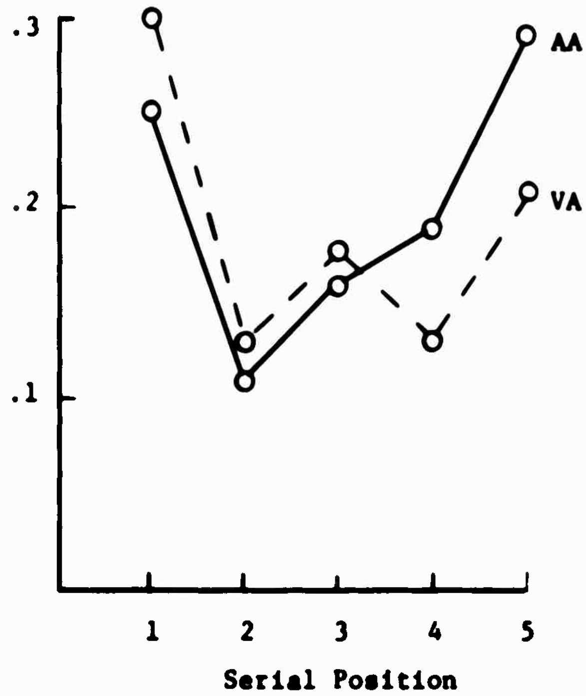

Figure 10. Mean correct responses for visual attenders (VA) and aural attenders (AA) across each of the serial positions.

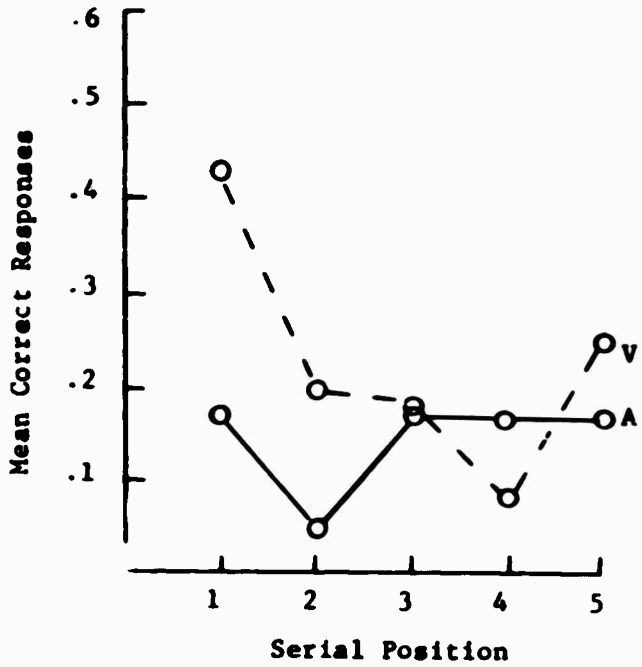

Figure 11a. Mean auditory (A) and visual (V) items correctly recalled by visual attenders.

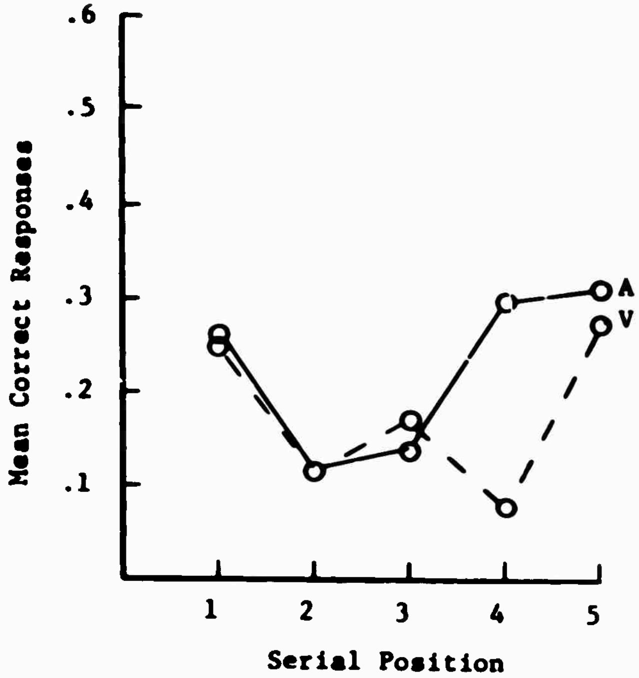

Figure 11b. Mean auditory (A) and visual (V) items correctly recalled by aural attenders.

($\bar{X}$ = .11) performance of visual attenders on the first two serial positions yielded t = 2.17, df = 376, p < .05, favoring visual recall. Conversely, a one-tailed comparison of auditory ($\bar{X}$ = .30) and visual ($\bar{X}$ = .18) performance of aural attenders on the last two trials yielded t = 2.06, df = 376, p < .05 favoring auditory recall.

In a similar manner, recall is a function of presentation modality and serial position. Figure 12 shows that visual recall is greatest during the primacy portion of the curve. A one-tailed comparison of correct visual responses ($\bar{X}$ = .22) to correct auditory responses ($\bar{X}$ = .16) for the first two positions yielded t = 1.32, df = 376, p < .10. Auditory recall, however, is greater on the next to last position but not the last position. Nonetheless, the t-test of recall of auditory stimuli ($\bar{X}$ = .26) compared with the recall of visual stimuli ($\bar{X}$ = .18) on the last two serial positions yielded t = 1.70, df = 376, p < .05.

As would be expected, Ss' performance improved over trials, $F(1,94)$ = 31.96, p < .01. Further, the interaction (p < .01) between sets of trials and serial position is apparently a function of the greatest gains in scores occurring on positions 1 and 3.

Analysis of Variance for the Bisensory Paired-Associate Task

A repeated measures design was used in this analysis. Aural and visual attenders served as the between-subjects dimension and responses to auditory and visual stimuli across nine trials served as the within-subjects dimension. The number of correct pairs across nine trials was analyzed separately. The inclusion of the latter measure in the first analysis would unduly inflate the results.

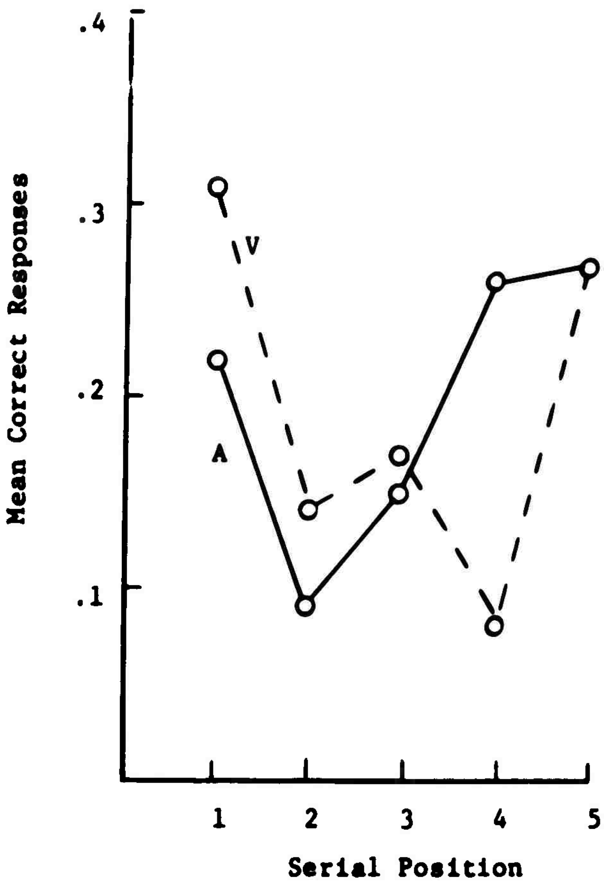

Figure 12. Mean correct visual (V) and auditory (A) responses across each of the serial positions.

<u>Analysis of auditory and visual responses</u>. A complete summary of the results of the analysis for correct auditory and visual responses is presented in Table X. No differences were found in performance as a function of modality preferences. However, recall of visual stimuli ($\bar{X}$ = 5.35) significantly (p < .01) exceeded the recall of auditory stimuli ($\bar{X}$ = 5.00). Comparisons of performance in blocks of three trials were made via Scheffe's test for multiple comparisons (Kirk, 1969). The analysis for the first block of trials yielded S^2 = 18.45, p < .05. Similar comparisons for the second (S^2 = 0.18) and third (S^2 = 3.74) sets of trials failed to yield any differences in recall of visual and auditory stimuli. Thus, the greatest difference in recall of visual and auditory stimuli occurred in the first three trials. The differential responding across the three blocks of three trials offers an explanation of the interaction (p < .01) between presentation modalities and trials. No variable interacted with modality preferences.

<u>Analysis of correct pairs</u>. The results of the analysis of the number of correctly identified pairs as a function of modality preferences shows that aural attenders correctly identified more pairs ($\bar{X}$ = 3.73) than did visual attenders ($\bar{X}$ = 1.53). It can be seen in Figure 13 that this superiority was maintained across all trials. In addition, there was an interaction (p < .001) between modality preferences and trials. Analysis of the performance of the two groups across three blocks of three yielded S^2 = 11.49, p < .01 for trials 1 through 3, S^2 = 26.62, p < .001 for trials 4 through 6, and S^2 = 38.38, p < .001, indicating that the superiority of recall for the aural

TABLE [illegible]

SUMMARY OF THE ANALYSIS OF VARIANCE OF
NUMBER OF CORRECT AUDITORY AND VISUAL RESPONSES
DURING A MODIFIED PAIRED-ASSOCIATE LEARNING TASK
AS A FUNCTION OF MODALITY PREFERENCES

Source	df	MS	F	p<
Between-Subjects				
Modality Preferences (A)	1	17.61	1.03	
Error (b)	89	17.10		
Within-Subjects				
Trials (B)	8	130.08	127.76	.01
A x B	8	0.90	0.88	
Error (w_1)	712	1.02		
Presentation Modalities (C)	1	51.34	21.74	.01
A x C	1	0.58	0.25	
Error (w_2)	89	2.36		
B x C	8	5.68	6.91	.01
A x B x C	8	1.34	1.64	
Error (w_3)	712	0.82		

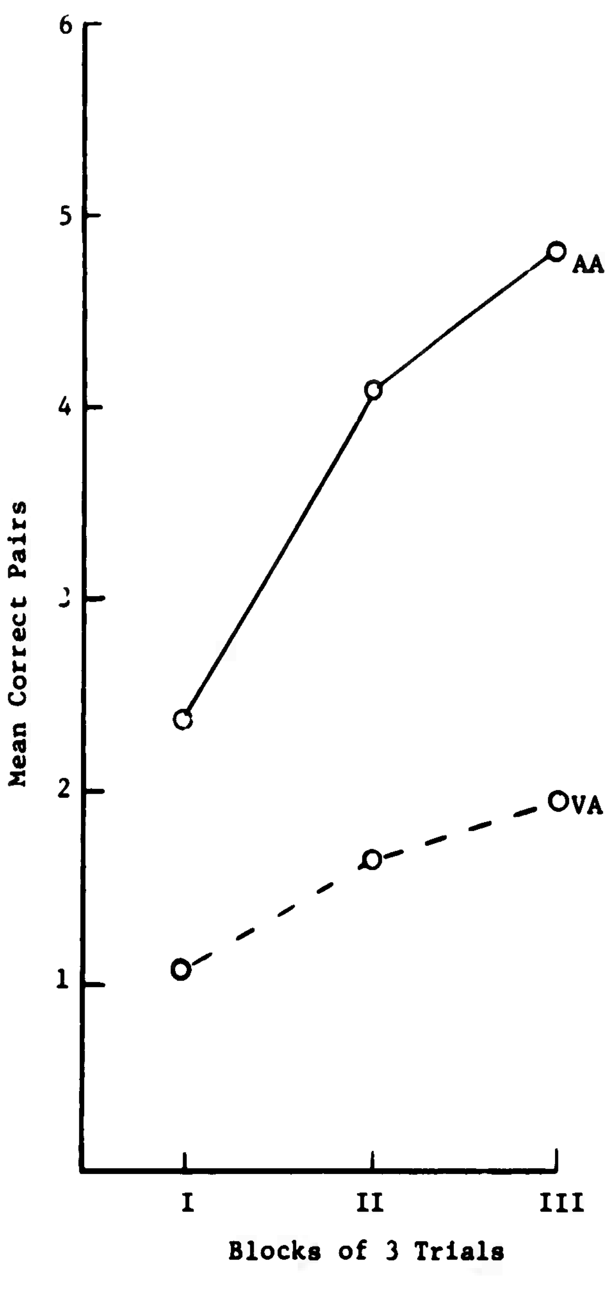

Figure 13. Mean correctly recalled pairs for visual attenders (VA) and aural attenders (AA) across three blocks of three trials.

attenders increased over trials. The summary of the analysis of variance for correctly recalled pairs is found in Table XI.

Analysis of Varianc for the Subjective Organization Task

Two analyses were performed on the data for this task. First, the number of correctly recalled auditory and visual stimuli across three presentations was analyzed as a function of modality attending preferences. In the second analysis, adjacency scores (described below) were compared to determine the extent to which Ss used modality of presentation as an organizational category when salient categorical organization was available for the stimuli.

Adjacency scores were defined as the proportion of the organized adjacencies to the number of possible adjacencies. Since an adjacency occurs when two words are recalled together, the number of possible adjacencies was one less than the number of correctly recalled stimuli. Chance adjacency responding was the proportion of organized adjacency responses that would occur randomly if all the stimuli were recalled with no organization of recall.

Analysis of correct auditory and visual responses. The results of the first analysis are presented in Table XII. Overall, there were no differences in performance for either group. However, recall of visual stimuli ($\bar{X} = 7.74$) exceeded recall of auditory stimuli ($\bar{X} = 5.29$) for both groups and, as would be expected, performance increased over trials ($p < .01$). There was, however, no interaction between modality preferences and presentation modalities.

TABLE XI

SUMMARY OF THE ANALYSIS OF VARIANCE OF NUMBER OF CORRECT PAIRS RECALLED AS A FUNCTION OF MODALITY PREFERENCES

Source	df	MS	F	p<
Between-Subjects				
Modality preferences (A)	1	1384.70	34.34	.01
Error (b)	126	40.32		
Within-Subjects				
Trials (B)	8	83.08	79.90	.01
A x B	8	17.53	16.86	
Error (w)	1008	1.04		

TABLE XII

SUMMARY OF THE ANALYSIS OF VARIANCE OF NUMBER OF CORRECT AUDITORY AND VISUAL RESPONSES DURING FREE RECALL AS A FUNCTION OF MODALITY PREFERENCES

Source	*df*	MS	*F*	*p*<
Between-Subjects				
Modality Preferences (A)	1	18.20	1.34	
Error (b)	92	13.61		
Within-Subjects				
Presentation Modalities (B)	1	770.02	47.42	.01
A x B	1	19.34	1.19	
Error (w_1)	92	16.24		
Trials (C)	2	1006.73	335.05	.01
A x C	2	0.34	0.11	
Error (w_2)	184	3.00		
B x C	2	26.07	8.39	.01
A x B x C	2	0.33	0.10	
Error (w_3)	184	3.10		

Analysis of adjacency scores. In the second analysis, mean adjacency scores were calculated across Ss for each of five types of adjacency scores: I, auditory adjacencies; II, visual adjacencies; III, categorized adjacencies; IV, categorized adjacencies within the auditory presentation; V, categorized adjacencies within the visual presentation. An adjacency score was defined as the ratio of the number of observed adjacencies to the number of possible adjacencies. Mean adjacency scores were calculated across Ss within each performance group. A summary of the mean adjacencies and their variances is presented in Table XIII.

The mean adjacency scores on each trial were compared to chance responding. Chance responding was the probability (p) of an adjacency response occurring at random during recall. Those comparisons failed to yield any modality of adjacency scores which differed from chance ($p = .50$) adjacency responding for either preference group ($p < .10$). Categorized adjacencies, on the other hand, increased over the three trials, $F(2,184) = 38.20$, $p < .01$, and by trial 2, categorized adjacencies exceeded chance ($p = .17$) level adjacency responding. The comparison yielded $z = 2.94$, $p < .01$. Neither of the groups differed in their categorized adjacencies from each other. A comparison of the two groups yielded $F(1,92) = .68$. There was no interaction between groups and trials. Categorized adjacencies within either modality failed to exceed chance responding. Indeed, in 6 of 12 comparisons, Ss performed at levels significantly less than chance.

TABLE XIII

MEAN ADJACENCY SCORES (Am) AND VARIANCES (V)
OF AURAL ATTENDERS AND VISUAL ATTENDERS
ON THE FIVE TYPES OF ADJACENCIES OVER THREE TRIALS

		VISUAL ATTENDERS			AURAL ATTENDERS		
		Trial			Trial		
Type		1	2	3	1	2	3
I	Am	37	43	45	50	41	45
	V	14	18	20	25	17	20
II	Am	61	66	59	64	62	58
	V	37	44	35	41	38	34
III	Am	24	24	34	18	24	34
	V	06	06	12	03	06	12
IV	Am	12	09	17	11	12	15
	V	01	01	03	01	01	03
V	Am	09	12	16	07	15	16
	V	01	02	02	01	02	02

Note: The adjacencies in and variances in this Table have been multiplied by 100 to eliminate decimals.

Analysis of Variance for the Bisensory Connected Discourse Task

The dependent measure for this task was the number of correct facts recalled from each of the connected-discourse passages. Both modality of presentation and familiarity of passages served as the within-subject dimensions. The two extreme groups of visual attenders and aural attenders were the between-subjects dimension. The design was thus a mixed design with 2 between-subject and 2 x 2 within-subjects dimensions.

The results of that analysis of variance are presented in Table XIV. No overall difference was found favoring either group. Neither were any differences found as a function of familiarity of the passages. However, recall of visual facts ($\overline{X}$ = 3.18) was greater than recall from the auditory passages ($\overline{X}$ = 2.31). Further, the superiority is concentrated in the recall of the low familiarity passages as reflected in the significant ($p < .01$) interaction between presentation modality and the familiarity of the passages. Using Scheffe's test, it was demonstrated that visual recall ($\overline{X}$ = 3.57) exceeded auditory recall ($\overline{X}$ = 1.70) on the low familiarity passages. This comparison yielded S^2 = 61.99, $p < .01$. Recall as a function of modality fails to differ in the more familiar passages.

One would expect that if modality preferences were to have any effect on the recall of facts for the passages that there would be a parallel interaction between modality preferences and familiarity of the passages, i.e., visual attenders should show greater recall of the facts on the low familiarity passages. This is, in fact, what occurred. Recall of facts as a function of modality preferences

TABLE XIV

SUMMARY OF THE ANALYSIS OF VARIANCE OF NUMBER OF FACTS RECALLED IN A BISENSORY CONNECTED DISCOURSE TASK AS A FUNCTION OF MODALITY PREFERENCES

Source	*df*	MS	*F*	*p*<
Between-Subjects				
Modality Preferences (A)	1	4.00	0.49	
Error (b)	89	8.20		
Within-Subjects				
Passages (B)	1	4.18	2.38	
A x B	1	9.40	5.35	.05
Error (w_1)	89	1.75		
Presentation Modalities (C)	1	69.45	13.69	.01
A x C	1	1.88	0.37	
Error (w_2)	89	5.07		
B x C	1	90.00	35.06	.01
A x B x C	1	0.28	0.11	
Error (w_3)	89	2.56		

significantly (p < .05) interacted with the familiarity of the presented passages. Following the presentation of the low familiarity passages, visual attenders ($\bar{X}$ = 3.06) recalled more facts than did aural attenders ($\bar{X}$ = 2.46). The comparison yielded S^2 = 7.36, df = 3,89, p < .10. No differences in recall were found between the two groups following the more familiar passages. The two interactions are depicted in Figures 14a and 14b.

Discussion: Experiment II

The results of Experiment II unequivocally support Experiment I. In some respects, they are more definitive since the role of visual modality preferences and auditory modality preferences on the processing and storage of information presented visually and aurally was more clearly in accord with the predictions derived from a separate sensory storage model. Much of the research under the rubric of aptitude by treatment interactions remains tenuous, thus, replicability of Experiment I was important in light of the essentially new definition of modality preferences as the difference in recall of auditory and visual stimuli which had been presented simultaneously. Furthermore, replicability offered an important source of validation too often ignored in educational and psychological research (Lykken, 1968).

As in Experiment I, the predicted disordinal interaction between modality preferences and presentation modalities was found using the missing units task. In addition, the augmented primacy effects expected for the visual attenders' recall of visual stimuli and the strong recency effects expected for the aural attenders' recall of

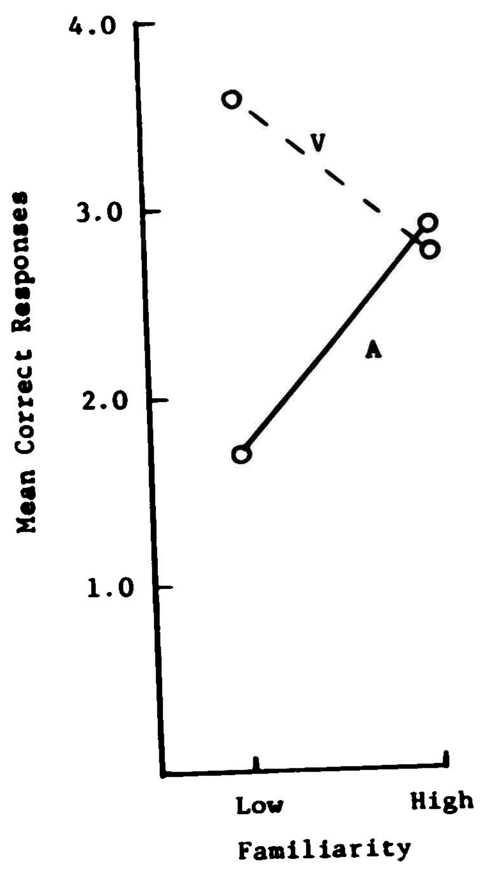

Figure 14a. Mean recalled facts as a function of visual (V) and auditory (A) presentations.

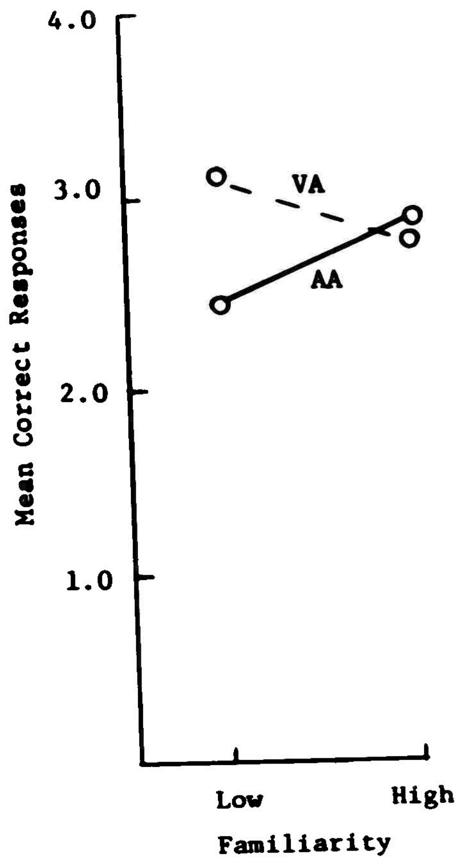

Figure 14b. Mean recalled facts for visual attenders (VA) and aural attenders (AA)

auditory stimuli were supported. Thus, the conclusion that one would glean from the experimental literature (e.g., Murdock, 1966, 1967) proposing an overall superiority of recall for auditory stimuli during immediate recall is, at best, inadequate.

In the more complex tasks, such as those requiring some type of categorical or semantic encoding, the visual modality emerged as the more salient of the two. This result is in essential agreement with Crowder and Morton's (1969) conclusion that as soon as any form of categorization or encoding occurs, modality effects will no longer favor the auditory mode. Either modality effects will be eliminated or the visual modality will emerge as the more salient. Also, the results of the bisensory connected discourse task parallel the results found by Mowbray (1952, 1953).

The salience of the visual dimension over the last three tasks might initially suggest that the results were purely a function of modality salience. However, if this were the case, the same salience should also have affected the missing units task which was an immediate memory task. That the visual salience did not extend back to the short-term memory task is demonstrated by the auditory superiority during the missing units task and also in the distribution of preference scores on the modality preference task.

Relative to the hypothesized interactions, the results of the complex tasks are, at best, suggestive. The connected discourse task was the only one of the three that produced effects which were even close approximations to the predicted interactions between modality preferences and presentation modalities. However, the results of

the other tasks described above offered clues as to the nature of the filtering or monitoring function which modality preferences provide.

The second experiment was conducted with the intent of replicating and extending the results of Experiment I. That the first purpose was satisfied is evidenced by the strong parallels of the results from the two experiments. However, the extent to which the validity of the construct was extended to tasks requiring complex encoding is, at this time, restricted. The modality preference measure may be too insensitive to account for variance in the more complex tasks or the latter tasks may include cognitive functions which override modality preferences. At least two alternatives seem logical for the establishment of a more sensitive measure: (a) a larger sample of observations, perhaps without as many warmup trials should be used; (b) new measures should be added which would allow a more adequate sampling of behaviors which are correlative to modality preference.

CHAPTER V

DISCUSSION

The results of the two experiments support the stability and validity of modality preferences as an individual difference variable which monitors bisensory auditory-visual inputs. The results indicate a strong interactive function of the aptitude with presentation modalities at least in short-term memory and are suggestive of influences in more complex tasks.

Separate Sensory Storage

The results of the missing units task corroborate Murdock's (1966, 1967) separate sensory storage model. Primacy effects for visual presentations and recency effects over auditory presentations were found paralleling the effects demonstrated in unisensory auditory and visual short-term memory experiments. The task used in the present study offered the additional advantage of providing a measure of recall from the first serial position. In contrast, the measure of recall is unavailable when the serial probe paradigm, such as that used by Murdock, is used. Thus, primacy effects for the recall of visually presented stimuli would be attenuated. If the first serial position were not included in the missing units task, as can be seen in Figure 13 merely by eliminating the first part of the curves, similar attenuation would have been found. The strongest support for Murdock's model, however,

is found in the performance of the visual attenders and the aural attenders. As was expected, the .ral attenders displayed very strong recency effects in their recall of auditory stimuli and no difference in recall of visual and auditory stimuli in the primacy portion of the curve. This result, by itself, would not have been exceptionally supportive of a separate sensory store model since that is essentially what has been found in the past. When, however, the results of the visual attenders are considered, strong contrast is found. Not only did visual attenders display greater recall of visual stimuli, but their pattern of recall displayed augmented primacy effects favoring visual recall. Thus, while visual attenders displayed strong primacy effects during the recall of visual stimuli, aural attenders showed enhanced recency effects in their recall of auditory stimuli.

The recall patterns of the visual attenders offer strong contrast to those which would be predicted by an auditory storage buffer model such as the one proposed by Atkinson and Shiffrin (1968) and Phillips, Shiffrin and Atkinson (1967). The stability of the results from the two experiments in the present investigation suggests that the conventional buffer models must be considered as inadequate in their present form. The Phillips _et al._ model suggests a probability function for the expulsion and loss of an item in the buffer on the presentation of new information. The greatest probability of expulsion is associated with the oldest item in the buffer. Thus the recall function for items from the buffer predicts that greatest recall is associated with the newest items in the buffer. While the model would appear valid across the entire population of _S_s (especially for

recall of auditory stimuli) the model is not adequate to predict the primacy effects of visually presented items and completely fails to predict the performance of visual attenders.

The proposition might be introduced to suggest that visual attenders simply monitor information until the buffer is filled. They then stop processing new information which would tend to induce an overflow within the buffer and require the expulsion of an existing item. If, however, this were the only factor affecting visual primacy, the Phillips _et al._ model would predict that those items held in the buffer would still be liable to the same decay function. Thus, the serial position curve would show an increasing slope during the early trials with a decrease in later trials. As can be seen in Figure 11a, this is not the case. The slope of the initial points on the serial position continuum for visual recall was a negative function. Thus, it must be concluded that although the hypothesis of constricted input may partially account for the results, it is not a sufficient explanation. Conversely, aural attenders display recall patterns from the auditory buffer model. Concisely, the contrast supports a separate sensory storage model. It is evident that there are individuals who differentially prefer one or the other of the sensory stores. Further, preferences act as monitoring filters controlling the flow of information for storage and retrieval.

The Pre-Categorical Role of Modality Preferences and Presentation Modalities

The data from the paired-associate task revealed no differences between aural attenders and visual attenders on the recall of auditory

and visual stimuli. However, large differences were found in the ability to associate the items as pairs. Further, that difference clearly favored the aural attenders.

It is proposed that the nature of the task contributed in some way to the establishment of the visual items as the more salient stimuli. Thus, whereas no temporal or spatial component affected the definition of the nominal stimulus, the visual items were probably processed first and acted as the functional stimuli. In terms of a two-stage model of paired-associate learning, the auditory stimulus would be processed as the response. Since aural attenders should have an advantage in storing the auditory stimuli, the problem of response integration would be reduced for the aural attenders allowing them to concentrate on the establishment of the correct association. Thus, differences in performance in this type of paired-associate task were likely to appear in the associative stage of learning. Schulz (1969) has also concluded that differences due to modality of presentation are most likely to be found during the associative phase of learning.

The preceding comments are conjectural but are certainly testable. This paired-associate task should be repeated with an attempt to force, with equal probability both auditory and visual items to act as functional stimuli. If the conjectures are valid, visual attenders should learn pairs in which visual items act as responses more rapidly than when auditory items serve as responses. Conversely, aural attenders would more readily learn pairs in which the response member was auditory. If presentation modality had further effects, there should be overall differences in learning each of the types of pairs.

The results of the connected discourse task present an enigma. The task which must have required the most complex encoding offered evidence of modality differences that favors one of the preference groups. Conjecturally, it is proposed that the Ss, when presented with two familiar passages were able to sufficiently alternate attention between the two passages. They could then select minimal cues from which they were able to retrieve, from long-term storage enough facts to meet the demands of the task. On the other hand, when Ss were confronted with the unfamiliar passages, they could not generate the facts from minimal cues. Therefore, they had to direct their attention toward one or the other of the passages. As would be expected from Mowbray's (1952, 1953) studies, the more likely passage to which they would attend was the visual. In effect, they may have covertly "shadowed" the visual passage while reading it thus blocking out the auditory. If this were so, the aural attenders would probably suffer more interference from the auditory "noise" than would the visual attenders.

The strongest results of the investigations reported here were found in that task which was a short-term memory task. The modality preference task was also a short-term memory task. The storage-retrieval processes for both, therefore, required minimal categorization of stimuli. It is proposed that the decision to attend to one or the other of the sensory dimensions is either a nonlinguistic or prelinguistic monitor. As the complexity of the task increased, the necessity for modal organization was diminished as the availability of semantic cues increased. The greater the availability of the linguistic cues, the less an individual with an aural or visual modality preference

would need to depend on the sensory features of the task. Gray and Wedderburn (1960) and Yntema and Trask (1963) demonstrated, for example, that the channel by channel regularity in recall during dichotic listening tasks reported by Broadbent (1954, 1958) could be modified if there was a salient inter-channel semantic organization available.

Conclusion

Modality preferences must be considered a nonlinguistic filtering function, overridden when more salient organizational cues are available. This conclusion is, of course, in agreement with others who have contended that modality effects occur prior to categorization (Atkinson & Shiffrin, 1968; Crowder & Morton, 1969; Murdock & Walker, 1969; Shiffrin & Atkinson, 1969). As information is input into the system, units are initially analyzed by their perceptual features. The extent to which that analysis serves as the organizational system for processing is a function of the availability of other, possibly more salient, cues. This would suggest that the free recall task should be repeated using lists which are not easily categorized by semantic groupings. If the salience of the semantic organization is reduced, the salience of modality features should be increased. That is, the necessity of using modality attributes as organizational features should be inversely related to the availability of linguistic or semantic cues.

The proposition that abilities may function at different levels of learning is not new. Fleishman (e. g., 1967) has proposed that individual differences affect motor learning skills during different stages. Games (1962) has suggested a similar proposition with verbal

learning tasks. However, the question, "Where do modality preferences have their greatest effects?" remains unanswered. The studies reported here indicate that both aural attenders and visual attenders are a viable subset of the population and indeed respond differently to auditory and visual stimuli. However, extensive research is still needed to delimit the extent to which this aptitude influences learning and recall.

CHAPTER VI

SUMMARY

This investigation studied the conditions under which individuals who differentially prefer to have information presented over one sensory modality as opposed to another, learn and recall stimulus materials presented over those two sensory modalities. The performance of visual attenders, i.e., those Ss who demonstrated preferred recall of visual stimuli, was compared to aural attenders, i.e., those Ss who demonstrated preferred recall of auditory stimuli, on a variety of bisensory auditory-visual tasks. It was assumed that in tasks in which independent information was presented simultaneously over two sensory modalities, S would be unable to attend to both modalities and therefore would select one or the other to which he would primarily attend. Further, it was anticipated that the modality to which S would attend was a stable response characteristic and represented a processing preference for one or the other of the sensory modalities. The present investigations were oriented toward the establishment of definable aural and visual modality preferences during bisensory auditory-visual stimulation which were stable across tasks and populations of Ss.

This investigation was comprised of two independent studies in which visual attenders and aural attenders were first identified on a bisensory auditory-visual digit-span task and were then compared for performance on additional bisensory tasks. Earlier studies which have alluded to modality or attending preferences in bisensory presentation

have used ths first emitted response to define the preference. The first emitted response, however, was not viewed to be sufficiently stabel to warrant its use for defining stable individual differences in modality preferences. However, the model on which the rationals was based assumed that the more correctly recalled set of responses should also reflect the set of stimuli that were processed first. Thus, the measure of modality preferences for this investigation was the magnitude and the direction of the difference in recall of visually and auditorily presented stimuli.

The first experiment was designed to test the validity of the concept of modality preferences within a relatively homogeneous group of Ss by comparing the performance of aural attenders and visual attenders on a missing units task. The results demonstrated overall superiority of recall of auditorily presented stimuli, supporting the results of earlier investigations comparing the efficiency of the two modalities in unisensory and bisensory presentation. Brief descriptions of the two tasks used in Experiment I are presented below.

Modality preference task. Two four-digit digit-spans were presented simultaneously to S. One set was presented auditorily while the other set was presented visually. Modality preferences were defined by the magnitude and direction of the differences in the recall of the auditory and visual digit-spans.

Missing units task. Two independent sets of five words were presented simultaneously to S. One set of words was presented visually while the other set was presanted auditorily. Four words from each set were then repeated on the same modality. The Ss task was to respond with the two missing words, one from each set.

Aural attenders recalled more auditory stimuli than visual stimuli while visual attenders recalled more visual than auditory stimuli. Further, the recall patterns revealed that aural attenders displayed more pronounced recency effects in their recall of auditory stimuli. On the other hand, visual attenders displayed more pronounced primacy effects in their recall of visual stimuli.

The second experiment was designed to validate the first by replication and to offer evidence to the generality of the concept. Following the definition of modality preferences, aural attenders and visual attenders were selected to participate in a series of test tasks. These tasks were designed to measure the role of modality preferences with different types of cognitive processes. In this way, data were gathered which were to describe the pervasiveness of the individual difference in question. In addition to the tasks used in the first experiment, three additional tasks were introduced. These tasks are described, briefly, below.

Subjective organization task. The subjective organization task was intended to study the strength of the modality preferences under the conditions of another, relatively well established, effect. Six sets of words were presented to *S*. During presentation, 18 words were presented on each channel simultaneously, three words from each set of six. Following the presentation of the bisensory list, *S* was given instructions to recall as many of the items in any order that he pleased. Three trials were given.

Paired-associate task. In this task, *S* was required to learn a list of assciates as in a paired-associate task. However, in this

case, an interchannel association had to be made. One half of a pair was presented visually and, simultaneously, the other half of the pair was presented auditorily. The Ss task was to learn as many of the pairs and as much of the list as he could within a limited number of trials. A modified study-test procedure was used.

Connected discourse task. In this final task, two paragraphs of approximately the same length, factual content and familiarity were presented to S in a bisensory manner. The S was then required to recall as many facts as possible from both paragraphs. This task served as the maximally dissonant condition under which modality preferences were studied in this investigation.

The results showed a disordinal interaction between modality preferences and presentation modalities, at least in short-term recall. That is, aural attenders recalled more auditory stimuli and visual attenders recalled more visual stimuli. In addition, the primacy and recency effects found in the first experiment were also replicated. The results were interpreted as supportive of a separate sensory storage model such as that proposed by Murdock (1966, 1967), since not only did aural attenders recall more auditory stimuli, but those auditory stimuli that were presented toward the later part of the list were more correctly recalled. Conversely, not only did visual attenders recall more visual stimuli, but the visual stimuli presented toward the beginning of the list were recalled more accurately.

On more complex tasks, the results were not as clearly defined. However, the results of the studies strongly suggest nonlinguistic factors in the effects of modality preferences and presentation modalities.

The results of the more complex tasks were interpreted to suggest that when a more salient feature is available for the encoding of verbal stimuli, i.e., there is a semantic category within which the stimuli can be organized, then the effects of modality of preference are negated. When, however, semantic features are unavailable or are not readily accessible, Ss should depend more on the perceptual features of the task for encoding.

The data suggest that in settings where information is arriving on more than one channel, individuals differentially sort out or select one or the other of the modalities and that modality which they select is a stable response characteristic. Thus, we might assume that in areas where audio-visual materials are used in instructional aids and where the information coming over both channels is not entirely congruent (or is somehow different), that some information may be lost because of the nature of multichannel stimulation. This loss may be augmented by the nature of selective attending factors as employed by each type of individual. Students, therefore, who consistently attend to the visual component of the task will suffer most when demands are made for information from the auditory channel. Likewise, aural attenders may be jeopardized when recall is demanded of visual information. It would appear, then, that in settings of auditory-visual concomitance of presentation more research is needed to delimit the effects of modality preferences.

Inasmuch as this was the initial study in the delimitation of the effects of aural and visual modality preferences on learning and recall, there are many areas that need further clarification. Many

of the results of this initial set of studies are suggestive and further investigations are warranted. A more complete definition of the role of modality preferences is required. Further, in view of the fact that recency effects were observed for aural attenders and primacy effects were dominant for visual attenders, other investigations are necessary to identify further effects on storage, recall, and retrieval of information.

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APPENDIX A

INSTRUCTIONS

MODALITY PREFERENCE TASK

This is basically a study of memory. You will be given several different series of numbers which you are to try to remember. Each time I present you with a series of numbers, I will ask you to remember them as soon as I am finished. You may have had some experience with a problem of this type in another setting where someone has presented you with a long string of numbers and asked you to repeat them. That is very similar to what I am going to do. However, the way in which I am going to present these numbers is somewhat unusual. Therefore, you will have to pay very close attention. Everytime I present the digits to you, I will actually be presenting two sets of digits at the same time. You will see one set of digits on the screen in front of you and, simultaneously, you will hear another set. I want you to try to remember <u>both</u> sets of digits. This is very important. You should always try to remember both sets of digits--those which you see and those which you hear.

Here is an example of what you are going to see and hear. [A bisensory sample problem is given.] If that were a regular trial, I would now ask you to remember as much of both sets of numbers as you could.

I am going to present you with several of these "double digit spans." In each, there will be four numbers in both sets. That is, you will see four numbers and you will hear four different numbers. I want you to try to remember as many digits from both sets as you possibly can. Just before the double digit span comes on, I will tell

you which set to recall first. Subjects in the past have indicated that this helps them while they get used to the task. Thus, if I say "auditory" just before the double digit span, that means I want you to recall the numbers that you heard first. If I say "visual" that means I want you to remember the numbers you saw first. I want you to recall both sets of numbers, but I will tell you which set to remember first. Is that clear?

When you are recalling the numbers, I would like you to write your responses on the paper which is in front of you. For each trial, there are two parts to a line. Write the set you recall first in the first half of the line and the second set in the second half of the line. Be sure to recall the set that I tell you to write first. If I say "auditory," I want you to write the auditory set first in the first half of the line and the visual set in the second half of the line. If I say "visual," I want you to write the visual set first. Is that clear?

Let me repeat. I will present several double digit spans. There will be four auditory and four visual numbers in each. Right after they have occurred, I want you to recall as many numbers in both sets as you can. I will tell you which set to recall first. Are there any questions?

Let's begin. Watch the screen and listen carefully.

Instructions Prior to the Criterion Trials

Now that you have had some experience with these double digit spans, you should be able to recall them well enough without my telling

you which set to recall first. I am going to present a few more of these trials. This time you will have the freedom to recall the numbers in the order most comfortable to you. Just before the presentation of a double digit span you will hear the word "ready." This is to indicate that the numbers are about to occur. Remember, you are to recall both sets. Are there any questions?

Watch the screen and listen carefully.

MISSING UNITS TASK

Now that you have had some experience with things presented visually and auditorily at the same time, I am going to change the task. This time rather than use numbers, I am going to use words.

I am going to present a series of five words. When I am finished, I will present four of those five words in a different order. Your task is to tell me which word is missing the second time through. Listen carefully, here is an example. Suppose I said, "Man, woman, mother, father, baby." Then I said, "Man, mother, woman, father." Which word didn't I present the second time? [Pause] That's right, baby is the missing word. That is what you will have to do. However, I am going to be presenting words in groups like this visually and auditorily at the same time. When I do, you will first see five words and, at the same time, hear five different words. Then you will see a blank screen. Then you will see four of the five words you just saw and hear four of the five words you just heard. You are to tell me the missing words. There will be two missing words. One word will be missing from the auditory set and one word will be missing from the visual set. I want you to try to remember both words.

This is an extremely difficult task and you are not expected to get very many answers correct. However, I would like you to do your best. You should select a strategy, a plan or a method, which gets you the most possible correct answers. Each person's strategy will differ. If you unsure of an answer, feel free to guess. Are there any questions?

Watch and listen carefully.

INTRODUCTORY INSTRUCTIONS: EXPERIMENT II

My name is Mr. Ingersoll. I am here from Penn State University. I am here to do a series of studies on how people your age learn and memorize under various conditions. I will be presenting you with a series of five different tasks in which I am asking you to participate. I will present three of these tasks today and two more one week from today. Each of the tasks is constructed to be difficult and you may find that you do not do well on some or all of them. This is to be expected so do not get discouraged when this happens. Just try to do your best on each of the tasks.

SUBJECTIVE ORGANIZATION TASK

In this task, I am going to present you with a long list of words. Your problem is to try to remember as much of the list as you can. Half of the list is going to be presented on the screen in front of you and the other half will be presented auditorily. I am going to present the same list three times and after each presentation you will have a chance to recall as many of the words from the list as you can. You will have three chances, so each time you should remember more and more of the list. You should try to recall again those words you re-called on the first presentation, on the second and third presentations.

We call this type of task a free recall task. As might be ex-pected from the name, you can recall the words in any order that you like. There are no restrictions on the order in which you are to write the words down. You can reshuffle them in any manner you like and mix the auditory and visual lists together. Recall the words in any order that allows you to recall the most possible words. Are there any ques-tions?

Watch the screen and listen carefully.

CONNECTED DISCOURSE TASK

First passage. In this task, I am going to try to imitate something that happens in the classroom. It occurs, for example, when you have a test in your fourth-period class and you try to do some last minute studying during your third-period class. What you end up doing is reading your book, perhaps below the level of the desk, while trying to keep track of what is being said in class--both at the same time.

This is basically what I am going to ask you to do. I am going to have you read a passage while you listen to a different passage at the same time. When the passage on the tape recorder is finished, I will ask you to recall as many facts as you can from both passages, the passage you read and the passage you heard. There is no restriction on the order in which you recall the facts or the format in which you write the facts down. Just try to recall as many facts as possible from both passages. Is that clear?

When I tell you to do so, turn over the paper which is in front of you and start reading while you listen to the other passage. Are there any questions?

Turn over your paper and start.

Second passage. I am going to ask you to do the same thing again with two new passages. That is, I want you to read one passage and listen to another. Then I will ask you to recall as many facts from both passages, as you can. Are there any questions?

Start.

PAIRED-ASSOCIATE LEARNING TASK

In this task, I am going to present words in much the same way as the other tasks. That is, as you see one word on the screen before you, you will simultaneously hear another word from the tape recorder. However, rather than think of the words in terms of auditory and visual sets of words, I am going to ask you to think of them as a pair of words. That is, they make up a pair of words with an auditory and a visual part. For instance, suppose I showed you the word "tree" and at the same time you heard the word "dog." Those two words would make up a pair because they occurred together: tree-dog or dog-tree.

I will present a list of seven pairs of words. I will present the same list nine times. After each presentation of the list, I will ask you to recall as much of the entire list as you can, either complete pairs or parts of pairs. That is very important. If you can recall a complete pair, that is very good. However, if you can only remember half of a pair, I'd like you to write that too. Say, for example, you only remembered the word "dog" of the tree-dog pair, you would write down the word "dog" during the recall period. Is that clear?

The pairs will always be the same through every presentation of the list. The order in which the pairs are presented will differ. For instance, a pair might appear first in one presentation and fifth in another. Are there any questions?

Watch and listen carefully.

APPENDIX B

CONNECTED DISCOURSE PASSAGES

CELL THEORY

About three hundred years ago, Robert Hooke used the newly invented microscope to look at the fine structure of plants. He observed that cork was not a homogeneous material, but consisted of tiny boxlike cavities which he called cells. Today, we know that what he actually saw were the cellulose walls of dead cells and that the important part of the cell is not its wall, but its contents. In 1839, a Bohemian physiologist named Purkinje, introduced the term protoplasm to describe the living contents of the cell. As more has been learned about cell structure and function, it has become increasingly clear that the living contents of the cell make up an incredibly complex system. Although protoplasm is still a convenient term for all the organized components of the cell, it is not a strictly meaningful term in any physical or chemical sense. At nearly the same time as Purkinje, two German scientists, Schlieden and Schwann, formulated a set of generalizations which has since developed into what is called the cell theory. The bodies of all plants and animals are composed of cells and new cells can come into being only by the division of previously existing cells. This implies that all cells living today can trace their ancestry back to ancient times. The cell theory includes a concept that the cell is the fundamental unit of both function and structure in all living things and this fundamental unit shows all the characteristics of living things. (Adapted from Villee, 1962, p. 35.)

ECOLOGY

At first glance, the world of living things appears to be made up of a bewildering variety of plants and animals, all quite different and each going its separate way at its own pace. Closer inspection reveals, however, that all organisms, whether plant or animal, have the same basic needs for survival, the same problems of getting food for energy, getting space to live, producing a new generation, and so on. In solving these problems, plants and animals have evolved into a tremendous number of different forms, each adapted to live in some particular sort of environment. Each has become adapted not only to the physical environment, that is, he has acquired a tolerance to a certain range of moisture, wind, sun, temperature, etc., but has also become adapted to the "biotic" environment. That is, to all the plants and animals in the same general region. The study of the interrelationships between living things and their physical and biotic environment is called ecology. Living organisms are related in two main ways, by their evolution and their ecology. One organism may provide food or shelter for another or produce some substance harmful to a second, or the two may compete for food and shelter. To study ecology in detail requires knowledge of the structure and functions of a wide variety of plants and animals. (Adapted from Villee, 1962, p. 82.)

THE GREAT STUPA

The Great Stupa at Sanchi, in central India, consists of a hemispherical mound set upon a circular base. At the top of this mound is an enclosed pavilion over which are layered parasols. The origins of the Stupa's form and meaning go back into the early history of India and of the near and far east. The Stupa is in the form of a burial mound much like those found in central Siberia. In India, the mound became a standard tomb for rulers and holy men as well as a place for the preservation of sacred relics. The mound was in use at the time of Buddha in the sixth century B. C. Buddha instructed his followers to build monuments containing his ashes and relics as reminders of his teachings. This led to the erection of eight original Stupas which are now lost. Those stupas were built on the sites of the great events of Buddha's life: his birthplace; the spot where he achieved enlightenment; the place where he preached his first sermon; and the place of his death. Other stupas protected his footprints and the stone slabs from which he taught. The stupas served as the focus of pilgrimages and worship which enabled the faithful to recall and share in Buddha's triumph over evil and ignorance, which moved him to emulation.
(Adapted from Elsen, 1962, pp. 32-33.)

STONEHENGE

One of the world's earliest surviving sacred playgrounds was built between 1800 and 1400 B. C. at Stonehenge, near Salisbury, England. The sacred enclosure is ringed by a 320 foot quarry ditch and bank within which are two large concentric circles of upright stones and stoneholes. Within these are two horseshoe-shaped stone series. These rings were built over a long period of time and at one point may have completely surrounded a wooden shrine. A few trilithons, two vertical stones topped by a horizontal stone cut to fit the curve of a circle, remain standing. These stones may have been a symbolic fence, a frame for a ritual, a spiritual abode--a temple. To the northeast, over 250 feet from the center of the circle and connected to it by a causeway, is the sunstone. Originally, a wooden gate stood between the sunstone and the circle creating a formal approach and entrance. In the center of the innermost horseshoe is a grounded, thin stone slab conjecturally referred to as the alterstone. A ring of white patches that lies near the girding ditch consists of shallow holes containing some evidence of cremation, indicating that the Stonehenge may have served as a sacred burial ground. In ancient times, holes in the ground were considered to be openings to the underground and were used as depositories for offerings to the underground spirits. (Adapted from Elsen, 1962, pp. 145-146.)

VITA

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PII Redacted

Mr. Ingersoll was employed as a fifth-grade teacher in the Webster School District, Webster, New York in the fall of 1966. In January, 1967 he was admitted to The Pennsylvania State University as an Educational Research Specialist Trainee. Since that time he has worked as a graduate associate at the Southwest Regional Laboratory, Los Angeles, California, as a research assistant to Professor Francis J. Di Vesta, and as an instructor of introductory educational psychology in the Department of Continuing Education of The Pennsylvania State University. During his tenure as a trainee and research assistant, the following articles have been published:

Di Vesta, F. J. and Ingersoll, G. M. The influence of pronounceability, articulation, and test-mode on paired-associate learning by the study-recall procedure. Journal of Experimental Psychology, 1969, 78, 104-108.

Di Vesta, F. J. and Ingersoll, G. M. The effects of semantic redundancy on children's identification of verbal concepts. Journal of Experimental Psychology, 1969, 80, 360-365.

He has been a student member of the American Psychological Association and the American Educational Research Association.

PII Redacted

The Effects of Presentation Modalities and Modality Preferences on Learning and Recall

by

Gary Michael Ingersoll

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in

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ABSTRACT

The performance of visual attenders, i.e., those Ss who demonstrated preferred recall of visual stimuli, was compared to aural attenders, i.e., those Ss who demonstrated preferred recall of auditory stimuli, on a variety of bisensory auditory-visual tasks. It was anticipated that in tasks in which independent information was presented simultaneously over two sensory modalities, S would attend primarily to one or the other of the modalities. The extent to which this was done represented a processing preference for one of the two modalities used.

The first experiment compared the performance of aural attenders and visual attenders on a missing units task. The results demonstrated overall superiority of recall of auditory stimuli, supporting earlier investigations comparing the efficiency of the two modalities in unisensory and bisensory presentation.

Aural attenders recalled more auditory stimuli than visual stimuli while visual attenders recalled more visual than auditory stimuli. Further, the recall patterns revealed that aural attenders displayed more pronounced recency effects in their recall of auditory stimuli. On the other hand, visual attenders displayed more pronounced primacy effects in their recall of visual stimuli.

The second experiment was designed to validate the first by replication and to offer evidence of the generality of the concept. Following the definition of modality perception, aural attenders and

visual attenders were selected to participate in a series of test tasks. In addition to the tasks used in the first experiment, three more tasks were used: a subjective organization task, a paired-associate task, and a connected discourse task.

The results showed a disordinal interaction between modality preferences and presentation modalities, at least on the missing units task, i.e., aural attenders recalled more auditory stimuli and visual attenders recalled more visual stimuli. In addition, the primacy and recency effects found in the first experiment were also replicated. The results were interpreted as supportive of a separate sensory storage model such as that proposed by Murdock (1966, 1967), since not only did aural attenders recall more auditory stimuli, but those auditory stimuli that were presented toward the later part of the list were more correctly recalled. Conversely, not only did visual attenders recall more visual stimuli, but the visual stimuli presented toward the beginning of the list were recalled more accurately.

On the other tasks, the results were not as clearly defined. However, the results of the studies strongly suggest nonlinguistic factors in the effects of modality preferences and presentation modalities. The results of the more complex tasks were interpreted to suggest that when a more salient feature is available for the encoding of verbal stimuli, i.e., there is a semantic category within which the stimuli can be organized, then the effects of modality of preference are negated. When, however, semantic features are unavailable or are not readily accessible, S should depend more on the perceptual features of the task for encoding.

END